

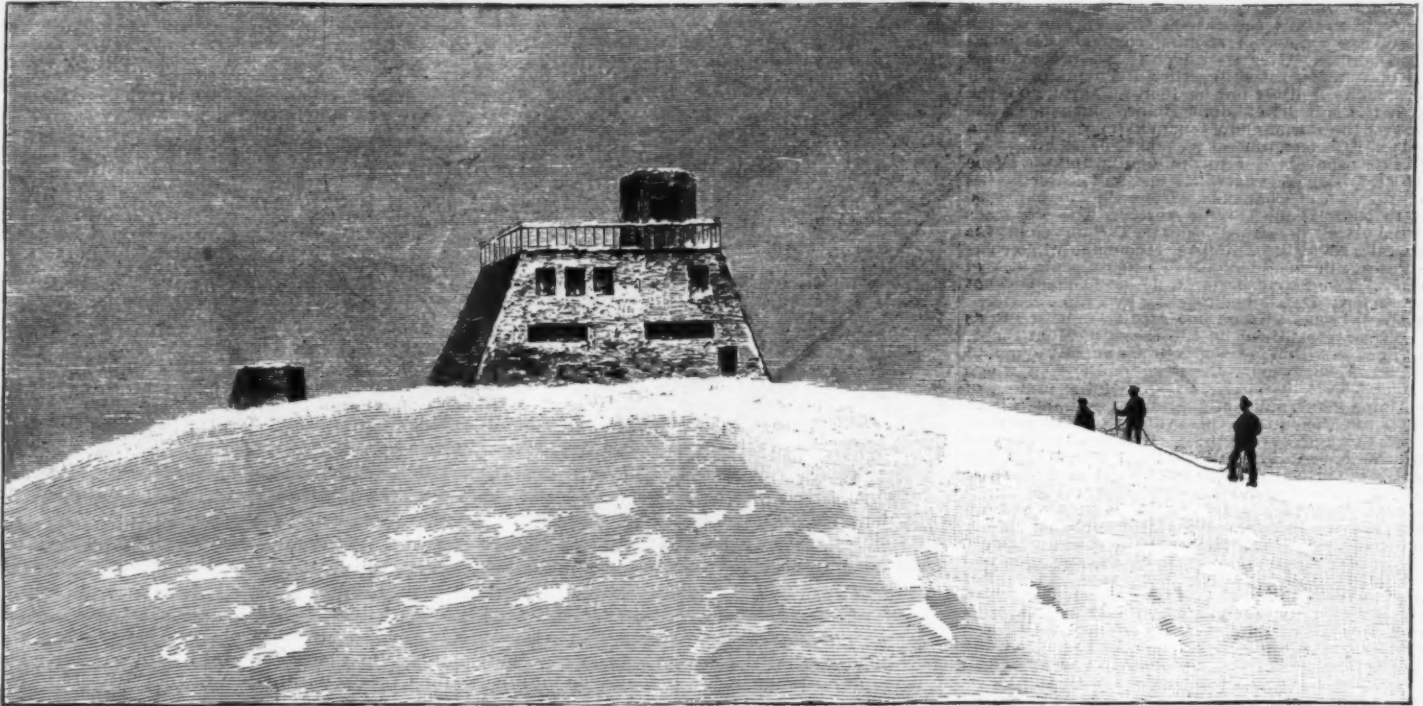
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THE JANSSEN OBSERVATORY ON THE SUMMIT OF MONT BLANC.



THE BOSSON GLACIER AND THE AIGUILLE DU MIDI.

MONT BLANC.

THAT portion of the Alps in which is located Mont Blanc is characterized not only by the fact that within it lies the highest point of Europe, but by a striking peculiarity in its formations. Its wealth in unusually fine glaciers, the number of so-called séracs (ice needles), scattered over it, and its aiguilles are quite typical of the region.

The nature of the séracs and the difficulties met with in their ascent are well brought out in one of our cuts, which shows a party of tourists, led by experienced guides, slowly making their way up one of these ice blocks on Mont Blanc. But still harder to reach than the tops of these séracs are the summits of the aiguilles.

It is said that, after an ascent of some of them, the summit of Mont Blanc is reached with relative ease. One of these aiguilles, the Aiguille du Midi, is visible in the background of our second illustration. In the foreground extends the Bosson Glacier, one of the finest of that region. A striking characteristic is its rugged surface. Over its ridges we see proceeding a party of tourists, roped together and equipped with alpenstocks. A little hut at Pierre Pointue, on the way to the summit of Mont Blanc, commands a fine view over the glacier and its surroundings. Here, at a height of 6,659 feet, tourists rest on their ascent.

The view spreads over to the aiguille and the Dôme du Goûter, both covered with snow, and nearer by lies the little town of Chamonix. From Chamonix the ascent to Mont Blanc is often started. The way leads past the place where the Glacier de Tacconnaz joins the Glacier des Bossons. This place is commonly known as the Passage de la Jonction. We reproduce a view of the spot. Two tourists are seen making the somewhat dangerous passage, linked together by a rope.

We have brought before our readers some scenes as the traveler meets them on the ascent of Mont Blanc. We will close with a few words to accompany our first illustration, which shows the aspect of the spot where the tourist finds his goal reached. On the summit of the Alpine giant, amid eternal snow, is built a little stone house, the Janssen Observatory. Small as it is, it represents a great enterprise. In August of the year 1890 Janssen, the distinguished Paris astronomer, was sent by the Meudon Observatory to ascend Mont Blanc with a view of making meteorological and spectroscopic researches. He started with twenty-two guides, and the necessary equipment, and successfully completed the work. The immediate result simply confirmed the observations made by an expedition two years before. But indirectly the expedition of 1890 also gave the first impulse toward the erection of an observatory on the summit of Mont Blanc. Janssen himself was the originator of the scheme; he secured the interest of several eminent men of France, among them the then president. A committee was formed to transact the business in connection with the enterprise, Janssen being president. As it came to the actual erecting of the building, the little hut of the engineer Vallot, half way up Mont Blanc, was found to be of great value as an intermediate station.

In 1891 a preliminary experiment was made—a

wooden hut was built on the site of the finally erected observatory. The experiment succeeded beyond the expectations of the builders, and soon the foundations for the observatory proper were laid. The house was made two stories high, the lower floor being below the surface of the snow, on one hand to make the house

The material was conveyed to its destination in eight hundred lots, weighing, together, about thirty thousand pounds. This work was begun in the summer of 1892, and, thanks to the comparatively fine weather that prevailed during its continuation, the construction was completed on September 8, 1893. At seven



A LITTLE HUT AT PIERRE POINTUE ON THE WAY TO THE SUMMIT OF MONT BLANC.

more stable, and on the other to obtain a somewhat moderate temperature in the bedrooms on the ground floor. The house was rested on screws, which were let into the snow, and which permitted of leveling it in case the snow should alter its position. This plan was conceived by Janssen, and approved by Vaudremer, the architect of the Academy of Fine Arts, of Paris.

o'clock in the morning of that day Janssen started from Chamonix to the observatory, where he arrived on the 11th at two o'clock in the afternoon. He took up his work at once, investigating the solar spectrum with regard to the question of the presence of oxygen in the sun.

Our illustration is reproduced from a water color



PASSAGE DE LA JUNCTION. ON THE ASCENT TO MONT BLANC.

painting by Janssen himself. The observatory is situated at a height of 15,632 feet above sea level. Our illustrations are taken from *Illustrirte Zeitung*.

THE ISLAND OF SAKHALIN.*

ALTHOUGH the remoteness of Kamchatka has, to a certain extent, familiarized us with, at any rate, the name of that dreary peninsula, the adjacent island of Sakhalin in the North Pacific Ocean still remains, to the majority of English readers, a sealed book. Of late years, however, its increasing importance as a place of exile for Russian political and criminal offenders has invested Sakhalin with a certain interest, derived, perhaps, more from penal associations than physical resources, which latter may, when fully developed, materially affect trade and commerce in the far East.

The island of Sakhalin is 584 miles in length, its breadth varying from 18 to 94 miles. The southern extremity is separated from the island of Yezo, twenty miles distant, by the Straits of La Perouse, and its western coast by the shallow Gulf of Tartary (at one point barely five miles across) from the mainland of Siberia. Although Dutch explorers are said to have landed here in 1643, the first reliable survey of the

circumstances, of about three months. One of the chief disadvantages connected with the island is that it does not at present possess a single harbor worthy of the name. The two principal ports, Alexandrovsky-Post and Korsakovsky-Post, are simply open, unprotected roadsteads, whence on the approach of stormy weather vessels must immediately put to sea. With convict labor, however, and abundance of necessary materials at hand, this should not be a serious difficulty to overcome. It has even been estimated that at Alexandrovsky-Post, on the western coast, a sheltered and secure anchorage could be constructed at a comparatively moderate outlay.

Sakhalin is mountainous, but the ranges, which run chiefly north and south, attain no great altitude, the highest peak, Mount Tiara, being scarcely 5,000 feet above sea level. The island is badly watered, there being only two rivers (the Tym and the Poronai) of any importance, and navigable for small craft for over a hundred miles. More than two-thirds of the island are covered by dense forests, chiefly coniferous, although the elm, poplar and maple are found in some districts, and bamboo is common in the uplands of the south. The climate is very variable. Winter lasts for about one hundred and ninety days, the mean temperature

According to the last census, taken in December, 1891, the settled population of Sakhalin numbered 19,644 souls, of whom 16,416 were Russians and the remainder Gilyaks and Ainors, or aboriginal tribes. The former, who are closely allied to the races inhabiting the banks of the Amur River in Eastern Siberia, lead a precarious existence, dwelling in winter in small settlements along the coast, and in summer leading a nomadic existence hunting and fishing. The Ainors, who originally came from Japan, now inhabit Yezo and the Kurile Islands, and are distinguished from the Gilyaks by their swarthy complexions, long faces and extraordinary hirsute appearance. Both tribes are, on Sakhalin, rapidly dying out. Of wild animals the bear, wolf and lynx are numerous in the forests. The elk is met with in the interior, and sables are caught in the north in considerable quantities, though their skins are of a very inferior quality. Horses and cattle have been imported from Siberia, but, although the former thrive and do well, the latter suffer much from climatic influences, and have as yet proved unsatisfactory. For sleighing purposes, dogs, and occasionally reindeer, are employed.

Sakhalin is, for administrative purposes, divided into three districts, viz., Korsakovsky-Post in the south, Tymovsk in the north, and Alexandrovsky-Post on the western coast. The latter, which is situated in the center of the coal district, is a picturesque, straggling town of about 7,000 inhabitants, consisting almost entirely of officials and convicts. This is the most important penal settlement on the island, contains the largest prison, and is, moreover, the residence of the governor of Sakhalin, a subordinate of the governor-general of Eastern Siberia. Alexandrovsky is garrisoned by about 1,500 men, and contains large foundries and workshops for convict labor, but most of the prisoners are employed in the adjacent coal mines of Dul. The coal is excellent for steaming purposes, but, owing to the difficulties of transport that at present exist, somewhat dear, and it cannot now be delivered for less than 12 rubles per ton at Vladivostok. The output in 1890 was 2,400,000 tons. Korsakovsky-Post, on the south coast, is the next largest settlement, containing about 5,000 convicts who are chiefly employed in agricultural pursuits. Although it may seem a paradox, the remaining prisons in the interior of the island, Derbynskaya, Rykovskaya and Onor, are not prisons at all, but huge wooden barracks, innocent of bolts and bars. Here, also, the work done is solely agricultural.

Prison life on Sakhalin is undoubtedly harder than on the mainland of Siberia, but, on the other hand, the actual confinement is of much shorter duration.

There are three classes of prisoners, viz.:

- (1) Convicts who, having served their time in prison, are free to live in a certain district and earn their own livelihood.
- (2) Convicts confined in prison, and compelled to work in the mines, foundries, or at agricultural labor.
- (3) Convicts confined to prison in chains.

The latter, of the dangerous class, are naturally kept under strict supervision and subjected to the most severe discipline. An ordinary criminal, however, sentenced to a term of, say, twenty years penal servitude, may by good conduct regain his provisional liberty in a quarter of the time. The state then provides him with a log hut, a plot of land and agricultural implements, and the district to which he is assigned becomes his prison. He is, practically, a free colonist whose wife and family may, if so disposed, join him, a free passage out from Europe being granted them by government. Political exiles are rarely sent to Sakhalin. At the time of the writer's visit there were but three residing at Alexandrovsky-Post.

Many of the better educated men in the first class occupy positions as government clerks, and earn as much as 50 rubles per month. Others find employment as domestic servants, night watchmen, storekeepers, or by working at the trade they have learnt in prison; but the majority prefer to accept the grant of land they are entitled to and take to farming.

Should a convict of the first class attempt to escape, he is immediately replaced in class 2, or, if violent and refractory, relegated to class 3.

The prisons are rough log buildings, cleanly and well ventilated, and the food provided amply sufficient, a convict of even the third class receiving meat four times and fresh fish three times a week. The hospital arrangements are, although primitive, satisfactory, and every prison contains a good school for children of both sexes.

Important changes have taken place of late years in the Siberian exile system, and the conditions under which Russian convicts now travel overland differ essentially from those of even a decade ago. It is now, moreover, probable that the long tramp across Asia will shortly be abolished altogether. All political and criminal offenders will then be transported direct by sea from Odessa (via the Suez Canal) to Sakhalin, and will thus be spared the fatigue and privations that must, even under the most favorable circumstances, attend the journey through Siberia.

Although the two principal towns on Sakhalin are connected by an overland telegraph wire, the interior of Sakhalin is comparatively unknown. Several rough tracks lead from the western coast to inland Gilyak settlements, but these are almost impassable for Europeans. There is only one road of any importance (about fifty miles long) leading from Alexandrovsky to the free convict settlements of Derbynskaya and Rykovskaya. Here the land has been extensively cultivated, and the contented looking colonists and neat homesteads speak well for the Sakhalin prison administration. Of the 30,000 acres of cultivated land on the island, nearly half is clustered around these pretty villages, where corn and vegetables are grown in large quantities, while hay is actually exported to Japan. It is said that the most fertile districts have not yet been opened up, and that the soil south of this point is even more favorable to the production of cereals.

Game and wildfowl are scarce in Sakhalin, but its rivers teem with fish of all kinds, while, off the coasts, cod, salmon and herring abound. The codfish are nearly all sun-dried and exported for food, but the bulk of the two latter are converted into manure for Japanese tea and paddy plantations, and fetch from £8

* Of the 5,000 convicts at Korsakovsky-Post, only 1,300 are actually confined in prison.

† This road has now been carried on a distance of about twenty-five miles to Onor.



SÉRAC ON MONT BLANC.

island was probably obtained in the year 1787 by La Perouse. Russian fur traders followed in the early part of the present century, but it was only in 1853 that, disturbances having occurred with the natives, a score or so of Cossacks were stationed at Dul, on the west coast. In 1867 negotiations were entered into by the Russian and Japanese governments for joint occupation of Sakhalin, but the subsequent discovery of coal, and consequent influx of Russian convicts, rendered this arrangement highly unsatisfactory. Further negotiations therefore ensued, with the result that, in 1875, the island was formally ceded to Russia, Japan receiving in exchange the entire Kurile Archipelago.

Sakhalin is by no means easy of access. Even during the open season (from May to September) but very few vessels visit the island, and, with the exception of the monthly arrival of convict ships from Europe, and a couple of small Russian trading steamers, there is no fixed service with Vladivostok, which, with the exception of Nikolaevsk, is the only Siberian port whence Sakhalin may in three days be reached. During the winter months the island is completely ice-bound and unapproachable by water. Communication with the mainland is then maintained by means of dog sledges, and the mails for Europe are dispatched across the frozen Gulf of Tartary—a journey, under favorable cir-

at this season being below freezing point. Spring commences about the middle of April, although, even in May, the thermometer has been known to fall as low as 21° F. Summer is as bright as it is brief, and the average temperature of the center of the island is then 80 to 85° F. The air at this season is mild and delicious, the sky blue and cloudless, and the grassy valleys carpeted with fragrant wild flowers. Some time before his visit the writer had read that "agriculture and gardening are impossible in the vicinity of Dul," and was, therefore, surprised to find that roses and geraniums flourish in the gardens of Alexandrovsky-Post, barely ten miles from the place in question. The warm season, however, is of very short duration; autumn, with her curtain of clouds and rain, veils the summer sunshine with fatal rapidity, and by the middle of August the island is generally shrouded in dense gray mist. By the end of October the coast is again ice-bound, and the whole island covered with snow several feet deep, which seldom entirely disappears until the following May. Notwithstanding these sudden and severe climatic changes, Sakhalin is not unhealthy, and, while prison statistics point to the predominance of rheumatic complaints, epidemics are of rare occurrence, and the death rate is low. Cholera is almost unknown.

* In Russian and French Prisons. By Prince Krapotkin. Ward & Downey, London.

* From the *Fortnightly Review*.

to £9 per ton. The largest and most important fishery on Sakhalin is owned by Mr. Denbigh, an old King's College man, who also trades extensively in seal and sable skins; but as fish manure is apparently, in his case, the most profitable article of commerce, the methods employed in catching and preparing the fish for exportation to Japan are perhaps worthy of notice.

At stated seasons of the year the herrings visit the coast in shoals for the purpose of depositing their roe, the first run usually occurring about the beginning of May, and being followed at intervals by others till the middle of June, when the fish disappear until the following spring.

A large trade is also done at Mauka in the long ribbonlike pieces of seaweed that, in the Gulf of Tartary, often cover the surface of the sea for miles. This is gathered, dried and shipped to China, where it fetches a good price and is considered a great delicacy.

Notwithstanding its climatic disadvantages, Sakhalin possesses so many resources that their development can only be a question of time. The Russians are a proverbially dilatory people; but there can be little doubt that the increase of population and enterprise, consequent upon the total abolition of Siberian exile, will within the next few years bring this lonely island, of which so few of us have even heard the name, into prominence and perhaps renown. HARRY DE WINDT.

PORTABLE LUMINOUS PROJECTOR.

THE curious property that platinum possesses of remaining incandescent for some time under the influence of hydrocarbons has long been known. This is an experiment that has been made in all courses of lectures since the time of Davy. It suffices to raise a fine platinum wire to a red heat, and then to place it over a saucer containing benzine, in order to have it remain incandescent. It is only within the last twenty years that advantage has been taken of this property in surgery, with the instruments devised by Dr. Paquelin and known as thermo-cauteries. As long ago as 1857, M. Mathieu, at the suggestion of M. Masson, professor of physics at Louis-le-Grand, constructed a surgical cauter based upon this principle; but it was not very successful, probably on account of defects in its manufacture. The wide use now made of the Paquelin apparatus proves that surgery has found therein a valuable auxiliary, and it is surprising that more of an endeavor was not formerly made to utilize those of Messrs. Masson and Mathieu.

In another order of ideas, Mr. Brenot, a skillful manufacturer of surgical instruments, who has for several years been constructing cauteries of iridescent platinum, has recently utilized this same property of platinum for making illuminating apparatus. The idea was suggested to him by Dr. Mareschal, the principal surgeon of the army, who, in his Tonkin and Madagascar campaigns, often had occasion to regret the absence of an intense light in the arrangement of ambulances.

The idea of utilizing platinum kept incandescent under the influence of hydrocarbons for illumination is not new, since, in 1875, M. Lodi-Montaigne took out a patent on this subject, although his apparatus was no more successful than the Masson-Mathieu cauter, and probably for the same reason. It does not, in fact, suffice to start from a known principle; it is necessary also to seek a sure method of obtaining a maximum of the effect to be produced. In order to keep platinum incandescent for a long time and at will, it is necessary to fulfill certain conditions that have been particularly studied in the apparatus that are daily operated by surgeons. The hydrocarbon generally employed is what is called gasoline. By means of a blowing apparatus, there is set up a current of air and gasoline vapor which must be mixed in certain proportions in order to give the maximum effect. A special two-way cock permits, in the Brenot apparatus, of finding, after a few tentatives, the exact point at which the mixture is made under the best conditions.

The illuminating apparatus in itself is very simple. It consists of a small sphere of platinum gauze (Fig. 1, No. 1), of a size dependent upon the purpose for which the apparatus is intended, placed in the center of a metallic reflector. The handle that supports the whole is hollow and filled with a sponge saturated with gasoline. At its lower part there is a regulating cock which connects it with the blowing apparatus. The latter may be of variable form, but, as a general thing, there is employed a rubber bulb which is actuated either with the hand or with the foot, when, as in the projector designed to illuminate the larynx (Fig. 1, No. 2), the two hands are occupied. In the experi-

ments recently made at Vincennes, there was employed with advantage air compressed in reservoirs carried upon the back and in which the supply of air was easily renewed by means of a small pump forming a part of the reservoir. These apparatus are found in the market, and are used for spraying grape vines. As the apparatus is not bulky, is very portable and is quickly set in operation, it is possible to produce an intense light at once in any place and in a determinate direction. With a projector having a reflector 0.24 m. in diameter, a surface of 40 square meters is illuminated at a distance of 200 meters, and the luminous intensity is sufficient to allow a person easily to read a newspaper at a distance of 100 meters. An illumination such as this will be a valuable aid in many military operations

"half tone" came about in this way. The difficulty of the early process workers was to find a satisfactory method of reproducing the half tones of the photograph in surfaces for mechanical printing. Taking the case of typographic blocks, it was easy to reproduce high lights by leaving the printing block hollow in those parts, so that they would not be covered with ink, and would deposit no color on white paper. It was also easy to reproduce shadows by leaving those parts in relief on the block so that the ink was deposited on them, and thus transferred a patch of solid color to white paper. But what would become of the half tones? It was not possible by the operation of passing a roller over the block to lay half a shade of ink on certain parts. Thus it was a picture without half



FIG. 2.—POACHER SURPRISED AT NIGHT BY MEANS OF THE PORTABLE PROJECTOR.

such as harnessing horses to batteries, lighting roads, engineering work, searching for wounded, urgent surgical operations, etc. From another view point in ordinary life also the Brenot projector will render many services, and we would especially mention the use of it for the search of malefactors and poachers (Fig. 2). It will perhaps be possible to apply it to the lighting of automobile carriages and bicycles.

For the latter, the simplest arrangement would be to carry a reservoir of compressed air and keep the pressure up by pumping from time to time by hand. But for automobile carriages it would be very easy to arrange a pump that could at will be connected with the motor or even be set in operation automatically when the pressure of the reservoir reached a point regulated in advance.

These are projects that we propose to those whom it may interest, the inventor of the pump not having the time to study it himself.—La Nature.

THE HALF TONE PROCESS POPULARLY EXPLAINED.*

By W. GAMBLE.

HAVING undertaken to popularly explain to you the half tone process, I ought, perhaps, in the first place, to make it clear to you what is meant by the term in its relation to process work. I have heard it stated that the process is called half tone because in the reproduction the picture is lowered to a half tone—that is to say, possessing neither high lights nor deep shadows. That explanation is, however, a mistake. The term

tones, and therefore merely a silhouette. But these early process workers were led to reflect that the wood engraver got his tones by means of lines of more or less thickness, and by placing lines closer or further apart; also that the aquatint etcher obtained his effects by varying openness of a resinous grain, while the mezzotinter and the steel plate engraver obtained their effects by the closeness and size of the stippling; and, again, the lithographer took advantage of the grain of a coarsely ground stone. Thus it was argued that if the half tone of a photograph could be broken up into some sort of a grain, the problem of making the photograph into a printing block would be solved. We know that this problem was solved, after years of patient experiment, by placing in front of the sensitive plate a ruled screen—that is to say, a network composed of crossed lines on glass.

The photographic image was thereby broken up into a grain, which reproduced the tones of the photograph by dots of varying size. Half tone reproduction was, accordingly, achieved; and, naturally, the method was called the half tone process. I do not know who first called it "half tone," but probably it arose in this way:

It was variously called by different workers according to their fancy; for instance, it was the "Meisenbach" process, so called after the patentee of one of the methods, while others called it the "nature" process; and, besides, there arose such names as "helio-type" and "luxotype."

But the public wanted to know what these strange terms meant; hence it was usual to add "a process for reproducing the half tones of photographs," and this soon became shortened into "the half tone process." So this name, ugly as it is, has stuck to the business.

Now let us see how this half tone process is worked.

The first and most important requirement is a screen. This consists of two pieces of plate glass cemented together, and on the inner sides of these two plates are ruled parallel black lines, the lines on the one plate crossing those on the other so as to form a network. The most perfect screens are those made by Levy, of Philadelphia.

His method of manufacture consists in coating the glass with a ground which will resist a glass etching mordant, cutting the lines through the film by a diamond point driven by a dividing engine, and then etching the glass left bare. The resulting furrows are filled in with an opaque pigment, and the screen thus formed is very perfect in the two essential qualities of opacity and transparency. These screens are ruled in various degrees of fineness or coarseness, the ruling determining the size of the grain points. Thus for poster work fifty-five lines per inch are used. For newspaper blocks to suit rough and rapid printing seventy-five or eighty-five lines are used. Various styles of printing are accommodated with rulings between 100 to 175 lines to the inch. It is possible to get screens of 200 to 340 lines to the inch, but the blocks from these are a bit too fine for British printers. Most of the half tone work you see about in the magazines and illustrated papers is done with screens of about 120 to 150 lines to the inch. It is to be noted that the finer the screen used, the greater the amount of detail; the coarser the screen, the greater the amount of contrast.

The screen is placed in the camera immediately in front of the sensitive plate, but not in contact with it. In fact, provision must be made for securing a variable distance between the screen and sensitive plate, for

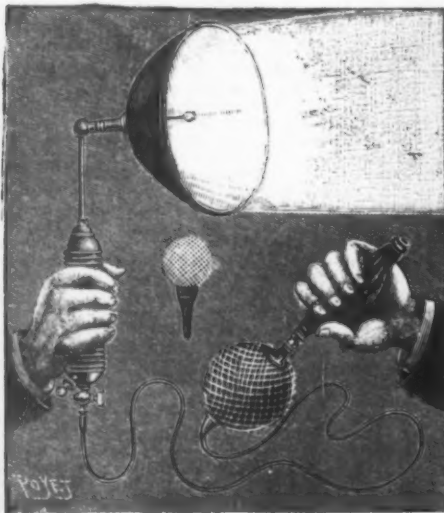


FIG. 1.—BRENOT'S PORTABLE LUMINOUS PROJECTOR.

1. Illumination at a long distance. 2. Medical projector for laryngoscopy.



difficulty of satisfactory photograph of the case high in those ink, and was also parts seated on color to the half of passing ink on out half

reasons which I will presently explain. In cameras made specially for half tone work there is in the back of the camera a screen carrier, which is made to travel to and fro by means of a lever or screw, and the distance at any point is shown by an indicator on the outside of the camera. When the dark slide is inserted and the shutter drawn, the screen carrier is brought forward as near to the plate as may be required. In the same way the screen may be brought up to the focusing screen until the right effect is observed, when the distance shown by the indicator is noted, and the screen can be set again to this distance when the dark slide is put in.

The old fashioned way of using the screen was in the dark slide, having two carriers—one for the plate remaining fixed and the other for the screen being separated to varying distances by means of strips of cardboard. It was a clumsy method, and I have here a newly invented slide in which there is a mechanical screen adjustment from the outside, and there is an indicator plate to show the distance. It forms a very compact arrangement, and its great merit is that it can be attached to any camera, so that if any of you want to dabble a bit in the half tone process you can fit up even a half plate camera with this slide.

The lens used for the process may be any good rapid rectilinear, but it must have a slot for Waterhouse diaphragms, not an iris, because it is necessary to vary the shape of the diaphragm openings. It is further necessary that the lens be fitted with a prism or mirror for reversing the negative, otherwise, as we print from the negative direct onto the block, we shall get a block which will yield an ultimate print the wrong way about.

The remaining fit up is pretty much in accordance with the ordinary arrangements for copying.

Having told you about the apparatus used, I must next explain to you the principles involved in the making of a half tone negative.

You want to know why it is necessary to place the screen at a certain distance, and how that distance is arrived at. Also why it is necessary to vary the shape of the diaphragm, and what is the shape required.

First, as to the screen distance. The early workers thought that the screen had merely a "chopping up" effect on the picture. The result of this want of knowledge was that the operator simply placed the screen close to the sensitive plate, and aimed at making it cast a sharp shadow of its lines on to the plate. The result was that the early half tone work had a raspy, gauze-like effect, which entirely killed all the delicate tone and detail of the picture, and even to this day some work has this characteristic as a result of the imperfect knowledge or perversity of the operator, who is much inclined to cling to obsolete methods of working. It was not till operators began to understand that the screen was an optical instrument, and not simply a sieve, that half tone work began to improve. Investigation into the theory of the screen working showed that under suitable conditions the screen might be regarded as a collection of tiny apertures which acted the part of pinhole lenses. It was just like the battery of "gem" lenses that you are familiar with for making postage stamp portraits, except that each aperture, instead of making a separate picture of the object, could only photograph the illuminated spot of light at the diaphragm opening.

Thus you will understand that there was a double action going on, viz., that while the picture was photographed through the screen by means of a lens, every aperture of the screen was doing a little business on its own account, namely, it was photographing the shape of the spot of light at the diaphragm opening. Or course, if the apertures of the screen were acting as pinhole lenses, they required a working focus; hence a screen distance was necessary.

Now, you will say, "We quite understand that this pinhole action may go on, but what is the use of it?" To explain it I must go forward a little to the printing process.

What we require in a half tone negative is a means of printing the picture on to the zinc or other metal plate in dots of varying size—big dots for black shadows, medium dots for half tones, and fine dots for high lights. Now if we are to print dots, we must have a negative, punctured, so to speak, with holes, but it is certain that if the lines of the screen were in contact with the plate we should not have a "perforated" negative, but the exact opposite, viz., a negative of separate dots, just as if you take a print from a piece of perforated zinc on to sensitive paper. But suppose you put the screen a little distance away and allow the pinhole action to form a larger dot, you can understand that it is possible to carry this spreading action until each dot touches and even overlaps its neighbor. Well, then, as the dots group themselves in spaces alternately, like the black squares of a chessboard, you will see that by making them spread until they touch, we get the "perforated" negative we require. In the old way, by assuming that the only object of the screen was to cast a shadow, the spreading of the dot had to be forced by long exposure and by vigorous intensification, which made the negatives hard and scenery, but by taking advantage of the pinhole action, the spreading is accomplished in a quick, harmonious and natural way. Another important advantage is gained. We find that the further the screen is from the sensitive plate, the less is its effect in breaking up the picture, and this also holds good to the extent that, if the screen is far enough away, the negative shows no screen effect at all; you would not know the screen had been there. Thus, you see that by taking advantage of the pinhole action, we can work our screen a considerable distance from the plate, and we get thereby more tone and detail. That explains the wide difference between the half tone work of today and that of even two or three years ago. The improvement is due to operators having found out, consciously or unconsciously, this little secret of the working of the screen.

The altering of the shape of the diaphragm had the same object in view, viz., the spreading of the dot in a suitable direction, so that we may get the "perforated" negative I have described. As the dot is formed by pinhole action, it is obvious we can make the dot any shape we please by altering the shape of the diaphragms. Thus we find that square dots give a better joining up to each other than round ones.

Once the operator has grasped these leading principles

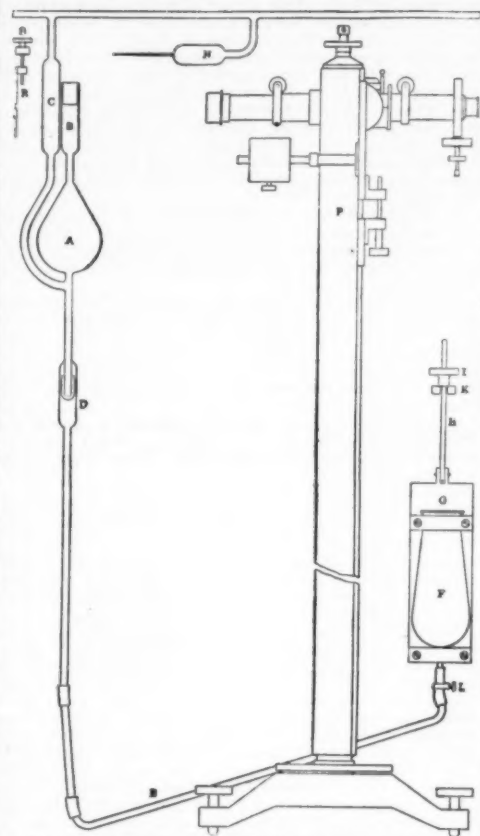
of the process, the negative making is an ordinary photographic operation, and either wet plates or dry plates may be used. There always has been a great prejudice in favor of wet plates, but for my own part, I find just as good, if not better, results can be obtained on suitable photo-mechanical dry plates.

The negative made, it is printed on to a zinc or copper plate sensitized with a bichromated film, generally of albumen, gelatine, gum, or fish glue, the latter being now perhaps most extensively used.

The process is analogous to carbon, the film, after being exposed under the negative, being developed by washing away the parts which have been protected from the light.

The development is continued until the zinc is laid bare between the dots. Then the plate is dried, and in the case of fish glue, is heated until the glue is made so hard as to be acid resisting. Then the plate can be etched until the dots stand in sufficient relief to yield a printing surface. The remaining operations are only those of fitting it for the typographic printing press by trimming up and mounting it to the height of type.

Now I hope I have made plain to you what this half tone process is, and I want to plead with you to give it a little more tolerance. It is not yet perfect, but it is a young process and will improve. One so often hears tirades against it, and it is often said that "process" is antagonistic to the interests of the photographer on the one hand and the artist on the other. I do not believe any such thing. On the contrary, it has widened the scope of photography and opened a more extensive field for the artist. Where photography was only a method of producing portraits and views ten years or less ago, it now takes rank as one of the graphic arts. In this year we have been summing up on every hand the advantages we have gained from the prolific inventions of the present reign, but I think it has been overlooked



INSTRUMENT FOR MEASURING SMALL GASEOUS PRESSURES.

how much has been done to three industries which have arisen out of the processes invented and brought to perfection in what has been called the Victorian age. I refer to electrotyping, stereotyping (by the papier maché process), and photo-engraving.

Take away these valuable auxiliaries of the printer, and we deprive at once the masses of the people of their cheap literature, whether it be in the form of books, newspapers or magazines. Pictorial knowledge is the most easily imparted, and has played a large part in the literature of this reign; indeed, we cannot measure how great a debt this age owes to photography and the photo-mechanical processes by reason of the wealth of illustrations which they have provided—not simply pictures that amuse, but illustrations which have made scientific, technical and general educational works far more valuable and instructive.

THE MEASUREMENT OF SMALL GASEOUS PRESSURES.*

By CHARLES F. BRUSH.

PRIOR to the invention of the McLeod vacuum gage, the measurement of even moderately small gaseous pressures was difficult, and subject to large errors. The introduction of the McLeod gage, however, early in the seventies, seemed to solve the problem. In its ordinary form, and for most purposes, this beautiful instrument admirably serves the purpose for which it is designed. But when very accurate measurements of pressures as small as a few millionths of an atmosphere are desired, its performance is extremely unsatisfactory and vexatious. As is well known, the chief cause of the difficulty is the unequal and variable capillary depression of the two small columns of mer-

* Read before the American Association for the Advancement of Science, August 12, 1897.

cury, whose difference in height indirectly serves as the measure of pressure. Accurate measurement of this capricious difference obviously avails nothing.

Three or four years ago I was engaged in an investigation requiring frequent and simultaneous measurements of slight but different pressures in two large glass globes connected by a capillary tube. For this purpose I constructed and carefully calibrated two large McLeod gages. The internal diameter of the mercury tubes was about three millimeters, and they were made from contiguous parts of the same glass tube selected for uniformity of bore. These gages were often compared by measuring the same vacuum with both; but they rarely gave concordant results. Indeed, it was not uncommon at high exhaustions for one or the other of them to indicate a negative vacuum; that is to say, less than no pressure at all. The cause of these two gages is cited because of the opportunity they afforded for comparison. In prior work I had, like most experimentalists, used but one gage; and while always suspicious of its indications, had no means of knowing how large its errors might be.

The phenomenon which I next desired to investigate is the spontaneous evolution of gas from glass and other surfaces in high vacua. For this purpose an accurate and entirely reliable means for measuring very small pressures was necessary, because I could not afford to wait months or years for the evolution of sufficient gas to be detected with certainty by the old gages. To meet these requirements I designed, constructed and learned how to use the modified form of McLeod gage which it is the purpose of this paper to discuss. It was deemed necessary to provide an apparatus capable of easy use, and giving results having a probable error not greater than a fiftieth part of a millionth of atmospheric pressure. My hopes of attaining this high ideal were far more than realized, as the sequel will show. Instead of having to wait days or weeks in the course of my investigations for the evolution of a measurable quantity of gas, as had been expected, the progress of evolution could be noted from hour to hour; and the increase in the rate of evolution due to a rise of one degree in the temperature of the laboratory was unmistakable.

The diagram herewith shows the essential parts of my apparatus. The bulb, A, of the gage, is made conical in its upper part, to avoid adhesion of gas bubbles when the mercury rises. This bulb holds about eleven pounds of mercury. B and C are the gage head and comparison tube respectively. They are nearly twenty millimeters inside diameter, and are made from contiguous parts of the same carefully selected tube. D is the usual air trap, and E is a long glass tube, with flexible pure rubber connections to the lower end of the gage stem and the mercury cistern, F. The latter is mounted on a carriage, G, which moves vertically on fixed guides. The height of the carriage is adjustable, at the upper end of its range of motion, by means of the screw, H, thumb nut, I, and forked support, K. The screw is pivoted to the carriage, so that it may swing out of the fork when the carriage is lowered. L is a pinch cock with screw, for regulating the flow of mercury, or stopping it altogether, while pumping out the trap, D. N is a bulb containing phosphorus pentoxide, to keep the interior of the gage and other parts of the apparatus perfectly dry. P is a very elaborate cathetometer for observing the mercury columns in B and C. This beautiful instrument has a revolving column with vertical scale, and vernier with microscope, reading to hundredths of a millimeter. The eyepiece micrometer reads directly to hundredths of a millimeter, and the divisions on the revolving head of the screw are so open that tenths of divisions are easily and certainly estimated by an experienced eye; thus permitting the micrometer to be read directly to thousandths of a millimeter. Of course the cathetometer is permanently located, not as shown, but with the objective of its telescope equally distant from the axes of the tubes, B and C, when it is alternately directed to them; and at such a distance that its micrometer readings correspond to a millimeter scale. The whole apparatus is located in a basement room, on a stone floor, whereby vibrations are reduced to a minimum.

The most important part of the gage is the head, B. The purpose of its great diameter is the reduction of capillary depression in its mercury column. But its size necessitates a very close approach of the mercury to its upper end, in order to sufficiently reduce its capacity. Yet the remaining space must be measurable by the cathetometer with the utmost precision. Hence the glass must not be distorted by heating, and the closed end just over the mercury must be sharply defined. In constructing this part of the apparatus, I selected a piece of heavy tubing which would just slip inside of B, with the least possible clearance. One end of this tube was closed as squarely as possible by fusion, and then ground with fine emery and a suitable tool to a convex spherical surface of long radius. Care was taken to make the center of curvature lie in the axis of the tube, and the ground surface was left unpolished to facilitate observation. A suitable length of the closed end of the tube was then cut off, slipped into B, and both tubes were fused together at their open ends as shown.

For calibrating the head, B, a ground glass stopper with a capillary duct was fitted to its neck, before the latter was sealed to the bulb, A. The head was then filled with mercury by boiling, thus completely filling the small space between its wall and the cap. After cooling, the stopper was inserted to expel all excess of mercury, and the whole weighed. Next the head was emptied and the mercury in the annular space distilled out. Again the head was very nearly filled with mercury, without allowing any to get into the annular space, and weighed as before; and the space between the top of the mercury and the convex end of the head was very carefully measured by the cathetometer. This process of weighing and measuring was repeated several times, with less mercury each time. Thus the capacity of a vertical millimeter of the head was ascertained, as well as the capacity that would remain, if the top of the meniscus of mercury just touched the convex end of the gage above it. Finally the neck was sealed to the bulb, A, and the capacity of head, neck and bulb combined was found by weighing them empty, and again filled with mercury.

For lighting the top of each mercury column, a narrow horizontal slit in an opaque screen, R, is used. The slit is covered with a strip of ground glass, and oblique-

ly illuminated by an electric lamp. The screen and slit are vertically adjusted by a thumb screw, S. The heat of the lamp is prevented from reaching the mercury columns and head, B, by a thick screen. This is very necessary.

In order to get the best results from the apparatus many precautions are necessary. After filling A and B with mercury, time must be allowed for the compressed gas to cool. The effect of changing barometric pressure is nearly eliminated by so regulating the quantity of mercury in F that its surface is in the small tube at the bottom of the cistern when the gage is properly filled. Its area is then very small, as compared with that in B and C. The height of the meniscus in both tubes is easily adjusted sensibly equal, by a little manipulation. I always raise the mercury above the point at which readings are to be taken, and then lower it, so as to read on a falling meniscus. This is highly important.

Some trouble was occasionally experienced at first from electrostatic induction between the mercury in B and the glass above it. This was shown by distortion of the meniscus when it was brought very near the glass. The difficulty was partially, but not wholly, remedied, by putting mercury in the outside open end of the gage head and connecting it by a flexible conductor with the mercury in the cistern, F. A complete remedy was effected by moistening the inside of the gage head with a dilute solution of phosphorus pentoxide. This became completely dried by the anhydrous phosphorus pentoxide in N, but was, of course, not dehydrated; and hence always remains conducting, and dissipates the static charge.

Large pressures, up to a thousand millionths or more, are readily measured with this apparatus, by finding with the cathetometer the distance between the mercury in B and the end of the head above it; from this is quickly calculated the necessary multiplier for the number of millimeters difference in height between the columns in B and C, also measured by the cathetometer, in order to express the result in millionths. For very small pressures, the micrometer wires are set at such a distance apart as to give a convenient constant (usually 2); and the column in B is adjusted this distance away from the glass; careful allowance being made for the thickness of the wires. Then the micrometer is used for repeated measurements of the difference in height of the mercury in B and C. The disturbing effect of bias is entirely eliminated by giving the micrometer screw a partial turn after each reading.

Thus the next measurement is made without any knowledge of its difference from the preceding one, until the eye is removed from the telescope.

In my early experience with the apparatus, unusually careful measurements of very small pressures were often made, to determine how far its indications might be relied upon. In this connection I quote as follows from my notes, under date of February 20, 1895, concerning the last one of the series of pressure determinations: "Following is the last reading in detail, showing the extreme accuracy of these measurements:

M.	M.	M.
0.432	0.438	0.441
0.441	0.4335	0.439
0.4335	0.4275	0.4305
0.426	0.450	0.435
0.4335	0.4425	0.432
0.4395	0.432	0.4185
0.4305	0.435	0.435
0.441	0.432	0.453
0.435	0.4215	0.4425
0.435	0.4245	0.438

Means... 0.4347 0.43365 0.43545

Mean of all the readings, 0.4346 M.

"Readjusted zero point of micrometer before each reading of each set. Partially emptied gage and readjusted capillary depression before each set of readings. The first series has no known source of error. The second and third series were made during wind squall, and surface of mercury was often tremulous. In the third series, capillary depression was perceptibly, though very slightly, unequal, in direction to make readings too high."

In the above quotation "M" means millionths of atmospheric pressure. The calculated probable error of the thirty readings taken together is only ninety-two hundredths of a unit in the third decimal place; that is to say, less than a thousandth part of a millionth of atmospheric pressure! The probable error of the three mean results, considered as single readings, is only eleven hundredths of a unit in the third decimal place of millionths. The net result may be expressed as follows, in terms of atmospheric pressure. Considered as thirty measurements:

$$0.000\ 000\ 434\ 60 \pm 0.000\ 000\ 000\ 92.$$

Considered as three measurements:

$$0.000\ 000\ 434\ 60 \pm 0.000\ 000\ 000\ 11.$$

Here we have the measurement of a total quantity of less than half a millionth of atmospheric pressure, with a probable error of only about a fifth of one per cent. of the quantity measured.

To show how small is the effect of variable capillary depression in the large mercury columns, the following measurements were made July 25, 1897. No correction was made of accidental capillary differences, but the columns were always observed with a falling meniscus. The zero of the micrometer was freshly adjusted for each reading; and before each of the six sets of readings the mercury was lowered, and then readjusted to the proper height in the gage head.

M.	M.	M.	M.	M.	M.
2.210	2.203	2.200	2.198	2.198	2.202
0.204	0.195	0.202	0.203	0.204	0.198
0.200	0.198	0.204	0.208	0.200	0.196
0.203	0.204	0.210	0.200	0.196	0.208
0.203	0.192	0.202	0.198	0.196	0.203

Means 2.2058 2.1984 2.2054 2.2014 2.1988 2.2014

Calculating the probable errors we have:

Six mean readings 2.20187 M. ± 0.00073 M.

All readings 2.20187 " ± 0.00059 "

The effect of not equalizing the capillary depression

is very apparent when these results are compared with the earlier ones quoted. But, on account of increased skillfulness of observation, due to long experience, the individual readings of each set are more uniform than before; so that the net result is better.

In this example we have the measurement of about two millionths of atmospheric pressure, with a probable error of only one part in three thousand of the quantity measured.

From the foregoing we may safely conclude that, with the apparatus described, small gaseous pressures may be easily measured, with a probable error of less than a thousandth part of a millionth of atmospheric pressure.

The smallness of this fraction is difficult to realize. It is comparable with a thousandth part of a milligramme in a thousand grammes; or a single kernel of wheat in two thousand bushels; or an inch and a half in the circumference of the earth; or the thickness of a sheet of tissue paper in sixteen miles.

RAREFIED AND CONDENSED AIR.*

AFTER reading Paul Guessfeldt's enthusiastic description of "mountain ecstasy," as he calls it, which the rarefied air of high altitudes produces and which he describes as consisting of "an increased sense of joy caused by an increased muscular activity, and a wonderful buoyancy of the feelings which at moments rises to ecstasy," we are tempted to follow him to those heights in order to experience these feelings which can be so easily obtained with a little physical exertion.

A different point of view is presented to us by D'Orbigny (1826) in an account of the sensations he experienced while crossing the highest pass of the Cordillera in Bolivia, which is 4,500 meters (about 15,000 ft.) high, on his way from the coast of Peru to La Paz. For several days before reaching the highest part respiration was difficult. His driver, the mule he was riding and his dog suffered so much that they were compelled to halt every 20 or 30 meters to regain their breath. While crossing the crest of the ridge he suffered intensely from pains in the temples, vertigo and extreme difficulty in breathing. Every movement of the body produced palpitation of the heart, followed by a feeling of general debility, until bleeding of the nose finally relieved him. During this attack of "mountain sickness" he saw two natives, who had overtaken him, hurry on their way, climbing the rocks with the greatest ease.

It is evident that D'Orbigny did not belong to an Alpine club, and did not have the necessary training, or else he would not have suffered so intensely at an altitude which has no effect upon those who now ascend Mont Blanc.

A man who has no practice in mountain climbing is apt to experience sensations similar to those which D'Orbigny described, while yet under the ordinary atmospheric pressure. For instance, in hurrying up a steep incline, say in the winter, when you sink into the snow with every step, you will very likely become short of breath, since the rapid climb prevents the full expansion of the lungs. This disturbs the circulation of the blood, which, being no longer freely admitted into the contracted lungs, collects in the veins. They swell up, the face becomes purple, the pulse beats are accelerated, and palpitation of the heart sets in. In case the exertion is continued, an attack of nausea is imminent, together with a feeling of faintness in the lower limbs, as the overworked muscles are deprived of their requisite supply of oxygen. A few long-drawn breaths usually suffice to remedy the disorder. By gradually becoming accustomed to walking and breathing slowly and regularly a further attack is prevented.

These symptoms, as they manifest themselves in the rarefied air of high altitudes, constitute what is known as mountain sickness, and persons unaccustomed to mountain climbing are frequently affected by it even while resting or when not exerting themselves. Here, again, the cause of the disorder is the insufficient expansion of the lungs, caused by the diminished atmospheric pressure, which renders respiration difficult.

But it may be objected that the energy with which we inhale the air is the same at high altitudes as below, and the rarefied air ought to penetrate into the lungs more easily. This is perhaps true, but, although we expand the chest during inhalation, the expansion of the lungs is only accomplished by means of the atmospheric pressure. The lungs are not attached to the inner surfaces of the thorax and can move freely. A wound in the thorax which admits the passage of air causes the lungs to contract, and all the exertions of the breathing apparatus will be powerless toward relieving this contraction.

As long, however, as the cavity of the chest remains closed and contains no air, the pressure of the air in the lungs acts from within outwardly, and by expanding the lungs will cause them to remain in contact with the sides of the chest as it expands during the process of inhalation. The ease with which the lungs are expanded depends upon the amount of atmospheric pressure which is brought to bear upon their elastic power of resistance, and this action consequently becomes more difficult as the lighter pressure of higher altitudes is reached. Let us suppose that the usual pressure is reduced to one-half, then the rapidity with which the lungs are expanded, although still greater than the usual rate of the chest expansion, is yet only half as rapid as when under the customary atmospheric pressure, and under certain circumstances this may seriously disturb inhalation.

Exhalation, on the contrary, is accelerated by the lighter pressure of a rarefied atmosphere. It generally takes place without the aid of the muscles which assist in the process of inhalation. The expanded parts, as the lungs, diaphragm, etc., contract to their original size and position by reason of their elasticity, as soon as the muscular force which was applied during inhalation is relaxed. The employment of the abdominal and intercostal muscles as an aid to exhalation is exceptional.

The only obstacle which retards the contraction of the lungs is the pressure of the outer air, which resists the outflow of the air from the windpipe and is diminished as the atmosphere becomes rarefied. Consequently the contraction of the lungs is greater and more rapid in a rarefied atmosphere. Exhalation is,

* From Science.

therefore, in general, a mechanical process, and as such is subject to a certain law according to which it can be performed on the summit of Mont Blanc in $\frac{1}{10}$ of the time required under the ordinary atmospheric pressure.

Humboldt tells us that newcomers in the vicinity of Quito, Ecuador, where the altitude is between 2,000 and 3,000 meters (11,800 ft.), have considerable difficulty in breathing, especially when talking rapidly. This is explained by the fact that the supply of breath usually reserved for the formation of sound escapes more rapidly and is therefore sooner expended. It has also been observed that some persons are unable to whistle where the pressure has only been diminished from 700 mm. (ordinary atmospheric pressure) to 500 mm. The whistling sound is produced by placing the lips in a certain position, and depends upon the rapidity with which the air is forced out of the lungs by means of the abdominal muscles. Naturally, the amount of muscular force so expended is still suited to the requirements of the denser air to which one has been accustomed. As the atmospheric pressure is diminished, the air escapes more rapidly and the expected sound is not formed. In order to learn again how to whistle, it is necessary to place the lips in another position and to apply the muscular force differently, which always requires considerable time and practice.

Physicians who have made a short stay at Davos, which lies at an altitude of only 1,600 meters (5,200 ft.), state that during that time their respiration was much accelerated, while there was an inability to breathe deeply. The explanation of this phenomenon is the diminished atmospheric pressure, which also causes an acceleration of the pulse beats—the inevitable result of insufficient lung expansion. Accelerated breathing at high altitudes affects metabolism by aiding in the removal of gaseous excretions, such as carbon dioxide.

Aerobats observe the acceleration of the pulse to be the first physiological change. They can reach a much higher altitude than mountain climbers without having any difficulty in sustaining respiration, as their muscular exertion is not so great. But the transition to the rarefied air is more sudden, and the increased difficulty in breathing, which now appears, although the aerobats are generally unconscious of it at first, results from an insufficient expansion of the respiratory organs, which renders them incapable of admitting the requisite amount of rarefied oxygen. The strength of his respiratory muscles is diminished; he finally loses control of his limbs and his senses are dulled. This was the experience of Ercel Spinnelli, Sivel and Tissandier, who, on August 15, 1875, reached an altitude of 7,000 m. (23,750 ft.) with an atmospheric pressure of only 300 mm. in two hours. They followed Paul Bert's advice and inhaled oxygenated air, as a result of which their strength immediately revived.

After a long sojourn in regions of high altitude the symptoms of mountain sickness pass away, as respiration is gradually regulated to suit the conditions of the rarefied atmosphere. The change which this necessitates is easily explained. In order to breathe deeply it is necessary to expand the lungs more slowly, and this is only accomplished by means of continuous unconscious practice, which strengthens the respiratory muscles. The members of Alpine clubs who make high ascents keep in practice by repeating their excursions frequently. Hence they are far less subject to mountain sickness than those who have had no previous training.

The wonderful feats of Paul Guessfeldt, which are described in the German Rundschau of 1892, are a good illustration of the benefits to be derived from such a training. He breathed and moved without any inconvenience at an altitude of about 5,500 meters, where the atmospheric pressure is equal to only one-half of the ordinary pressure. In ascending Mount Aconcagua, in Chile, he had no difficulty in breathing until after the altitude of 6,000 meters had been reached, and even then he was finally able to ascend to the summit, which has an elevation of nearly 7,000 meters, or 23,910 ft., an altitude at which aerobats are compelled to have recourse to their supply of oxygenated air.

A distinguishing characteristic of the air of high altitudes as compared with that of lower regions is its freedom from moisture. The atmosphere is so dry on the plateaus of the Andes in Peru and Bolivia, where the altitude ranges from 3,600 to 3,900 meters, that the flesh of butchered cattle can be dried in the open air. The two explorers D'Orbigny and Wedell both report that the sheep which are killed there are split open and salted, after which they are hung up in the open air and are dried in four or six days.

The ocean is the chief source of the moisture contained in the atmosphere; consequently, the interior of the continents is drier than the coast regions, and in the same way the moisture decreases as we rise above sea level. The lower stratum of air up to about 2,000 meters (6,500 ft.) contains one-half of the whole amount of aqueous vapor in the atmosphere, and here the cloud formations are densest and most frequent, while above this altitude the sky is much clearer.

It is a well-known fact that extreme dryness of the atmosphere stimulates the nervous system, making one feel brighter and more inclined for both physical and mental activity. The inhabitants of very dry regions, according to the reports of explorers, are free from any tendency to obesity.

In trying to escape from the hot air of the cities in the summer we look for a place which is situated higher above sea level, because we know it to be cooler. In the torrid zone, resorts with an elevation of from 2,000 to 3,000 meters are popular. In spite of being nearer to the sun, the air is cooler, as the sun's rays have practically no effect upon it. The air allows the rays to pass through it freely, but receives its warmth from the dark heat rays which are reflected from the earth after the sun has warmed it. The lower strata of air are, therefore, always warmer than the upper. But the plateaus of the highlands are cooler too, as well as the summits and crests, for their rarefied atmosphere is incapable of absorbing as much of the heat reflected by the earth as the denser atmosphere of the lowlands. Although the surface of the earth receives more heat at high elevations, it is immediately reflected back into space without heating the air to a corresponding degree. This is evidenced by the fact that at high altitudes the difference of the temperature in the sun and in the shade is greater than in the lowlands. But the effect of the sun's rays is felt more keenly at a

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high elevation, so much so that persons staying at Davos can enjoy a sun bath in a sheltered spot even in the cold of winter, although wearing much thinner clothing than at home.

It takes a visitor at Cerro de Paseo, in Peru, which lies at an elevation of 4,500 meters, 10 or 12 days to thoroughly regulate his respiration to the conditions of the atmosphere. In case his suffering is greater at first, it often happens that he is compelled to make a temporary change of residence to a point some 1,000 meters nearer the level of the sea. Even during the descent he begins to breathe more easily and feels brighter and stronger.

The inhalation of air which has been artificially condensed, as in a pneumatic cabinet, produces quite similar sensations. An asthmatic patient placed in an atmosphere where the pressure has been augmented by nearly one-half will immediately be enabled to breathe more freely; respiration becomes slower; his excited nerves are quieted, and he feels imbued with renewed vigor.

The mechanical action of condensed air as it affects respiration is the reverse of the action which takes place in rarefied air. A higher atmospheric pressure facilitates the expansion of the lungs, and the condensed atmosphere, by delaying the egress of the air expelled during exhalation, finally effectuates a distended condition of the lungs. The pulse beats become slower at the same time, and the veins, which were surcharged with blood under a diminished pressure, are now emptied more thoroughly. This is the cause of the decrease of congestive conditions in a pneumatic cabinet. The amount of oxygen which we inhale is increased in proportion to the increased condensation of the atmosphere, thereby enriching the blood. If the treatment is continued, this soon makes itself manifest by an increased appetite and a healthier complexion. The invalid gains in strength and vitality. Respiration is facilitated even outside of the cabinet, and by such observations we perceive that the employment of condensed air has after effects, which supposition the spirometer confirms. A deeper and more quiet respiration has been observed in some cases after the elapse of one and even two years.

The air which is admitted into the pneumatic cabinets by means of air pumps can be kept at any degree of condensation. The cabinets, which are of various sizes, are arranged to admit from three to fourteen persons, and naturally great care is taken to have a good ventilation. They generally stand in the center of a lighted hall: their walls are composed of sheet iron and provided with windows which admit ample light for reading. The cabinets are used exclusively for the cure of catarrhal diseases, to facilitate the respiration of asthmatic patients and to improve the condition of the blood of anemic persons, in which cases the condensed air frequently proves beneficial after all other remedies have failed.

The first pneumatic cabinet was established somewhere in the thirties at Montpellier by a physician named Tabarie, who later gave the management of it into the hands of a physician. Pravaz soon followed his example at Lyons, and the reports of the two scientists as to their observations made on healthy and diseased persons were presented before the French Academy and to the medical world in quick succession. About thirty years later the idea of putting condensed air to this use spread from France to other countries of Europe, and the largest institution of this kind at present is at Reichenhall, the property of E. Mack, in which fifty-three persons can make use of the heightened pressure at the same time.

In 1841 M. Triger, a civil engineer, introduced in France the idea of using a heightened atmospheric pressure in building subaqueous works, and this gave an opportunity to observe what effect an atmospheric pressure which was much higher than that of a pneumatic cabinet would have upon the workmen. The work under pressure is carried on in an iron shaft, the sides and top of which are airtight. It is sunk to the bottom like a diving bell, while the upper end protrudes above the surface of the water. The fresh air which is continuously pumped in from above expels the water below, leaving the bottom free to be worked upon. The shaft sinks deeper and deeper as the earth is removed, until there may be a pressure of three and one-half or nearly four atmospheres. A pressure of ten meters of water is equal to about one atmospheric pressure.

The effect of the condensed air upon the laborers was found to be surprisingly favorable up to a pressure of two atmospheres. The hard work was accomplished more easily and with less fatigue than in the open air, and in such exertions as running up a ladder they did not get out of breath. Even after working hours the men felt stronger and in better spirits.

But when the pressure exceeds that of two atmospheres the men begin to have certain unpleasant sensations, such as itching and pains and swelling of those muscles which are strained the most. These symptoms do not, however, appear while under the heightened pressure, but make themselves felt during the time that the men are under the normal pressure, and pass away again as they return to their work. The overseers are exempt from these effects. They receive instead a mental stimulus which is manifested by an increased impulse to talk.

If the atmospheric pressure is still further increased, the resistance against exhalation becomes stronger. The action of the respiratory apparatus is weakened by the increased distension of the lungs until it finally becomes almost imperceptible: speech is difficult and whistling impossible. The result of the too rapid contraction of the lungs under a diminished pressure which prevents whistling is the same as that which follows when the egress of the air expelled by the lungs is delayed.

The enlivening influence on the workmen is diminished as soon as the pressure exceeds that of three atmospheres. The slow and imperfect performance of the respiratory function begins to have a detrimental effect upon the gaseous interchange which takes place in the lungs by causing the carbon dioxide to be retained in the blood. The laborers become more easily fatigued, and a decrease of appetite is followed by loss of flesh, if they continue the work. We find, therefore, that there is a limit to the condensation of air, which a man cannot overstep without detriment to himself, but there is a wider limit in this direction than in that of rarefied air.

Experience proves that a temporary change from the normal pressure to an increased or diminished pressure is pleasant and also benefits vitality in various ways. We are able to ascend to any altitude at which the air is rarefied to the desired degree, but the privilege of choosing a denser atmosphere in which to live is denied us. It is only from a few places at very high elevations that convalescents can be sent down to a lower altitude, where they quickly recover by inhaling air which is more condensed and contains a larger proportion of oxygen. The inhabitants of the lowlands are confined to the pneumatic cabinet in their search for these benefits. From what has been said regarding the mechanical change which respiration undergoes, we gather that a temporary employment of condensed air, besides its various other effects, would be a good preparation for the proper performance of the respiratory function in a more rarefied atmosphere.*

G. VOX LIEBIG.

University of Munich.

THE ZODIACAL LIGHT.

By Lieut.-Col. E. E. MARKWICK, F.R.A.S.

THE season when this phenomenon is visible after sunset is now approaching, and it may be interesting to take stock of what we know about it, which, after all, seems to be surprisingly little. It is generally dismissed in the text books with a pretty short notice, and sometimes is not mentioned at all. Although it can hardly be called a popular object in the sense that Mars or Jupiter is, still there must have been a great number of observations made of it at different times, and one looks for a corresponding definite advance in our knowledge of its interior economy. But the conditions of its visibility in our latitude render exact observation extremely difficult. Like the inferior planets, Mercury and Venus, it is seldom, if ever, seen more than three or four hours after sunset or before sunrise, and cannot be observed on the meridian. Again, its tenuous and ethereal character renders it a difficult matter to note definite particulars of its shape, size or position. In these respects no instrument is of the slightest service; but the observer should be one with a keen eye, which can take in a large area of the sky, and is quick in apprehending differences in brightness of particular areas. No telescope can do this, and, even with a binocular, the field of view commanded is far too small. The best way is to sweep the eye rapidly right and left, up and down—that wonderful faculty of “averted vision” assisting to note very faint degrees of light.

My own experience, based on some sixteen years of observation in different latitudes, is that, provided one has a clear country horizon remote from the glare of towns or electric lights, with a dark clear sky in January or February, there is no difficulty to the ordinary observer in England in detecting, soon after sunset, the pearly cone of the zodiacal light sloping upward from the sun's place. The boundaries are generally ill defined, and the apex has usually to be imagined more or less, so exceedingly delicate is the glow toward the extremity of the cone. Guillemin, in “The Heavens,” has a very delicate plate of it, as seen in Japan. In this picture it looks fainter than it is sometimes seen in England.

For all practical purposes the axis coincides with the plane of the ecliptic.

An open horizon has a good deal to do with its visibility. For years I looked carefully for it in England without success, and I think the reason was that trees and other prominent objects, dark against the western sky, must have put my eye out of focus for the faint light. There are some who have not the power or capacity for this class of seeing, and I have before now, when in southern latitudes, pointed it out, quite blazing, to a friend, who, however, could make nothing of it, although it was literally staring him in the face.

Humboldt, in his “Cosmos,” has some most interesting remarks on the subject, the more so as they are based on personal observation and considerable literary research.

My first observation of zodiacal light was in Natal, where it was at once palpable. It was in the dry, clear air of the uplands of South Africa, however, that it was seen to the greatest perfection; while in the Transvaal and in Bechuanaland the light was almost blazing—at least, it seemed so to an eye accustomed to astronomical phenomena, not to bonfires. Unless one has been in these circumstances of latitude and climate, it is impossible to imagine what an exquisitely delicate and ethereal object the light is. For there one has great advantages, notably in the transparency of the atmosphere, and the fact that the light is perpendicular, or nearly so, to the horizon. It is extremely difficult, when it slopes at the angle it does in England, to judge of the relative sharpness of the margins; a point which I have studied of late in connection with Dr. Veeder's theory of its duplicity. At Gibraltar, whence I write, it is often most beautifully seen as a whole, and Humboldt refers to its greater intensity in Spain, on the coast of Valencia, etc. From our coign of vantage we have the privilege of looking across the Bay of Gibraltar, with the range of hills beyond Algeiras in the distance, and, except for occasional shipping, this view is free from artificial illumination or glare.

Humboldt thinks that the zodiacal light was unknown to, or at least not mentioned by, the ancients. The word *trabes*, occurring in Pliny, which some consider means the phenomenon in question, refers to meteors, bolides, and comets. According to Humboldt, it is first explicitly described by Childey, chaplain to Lord Henry Somerset, in his “Britannia Baconia.”

Dom. Cassini was the first to investigate the phenomenon in its relations in space in 1683. Cassini, Humboldt says, maintained that a phenomenon observed by him at Bologna, also by Chardin in Persia, in 1668, was the zodiacal light, but that really this was the tail of the comet of 1683, whose head was at the time below the horizon. This calls to mind the great comet of 1883, which I first saw after perihelion in the beautiful sky of Natal about 4 A. M. The head was below the horizon and the tail sloped upward for many degrees—a most extraordinary vision. Never can that

supremely beautiful sight be forgotten, as the comet majestically rose and displayed himself, surrounded by a gauze veil more ethereal than any bride's.

But no one could for a moment mistake the comet of 1883 for the zodiacal light. On the contrary, the view of the great comet of 1880, which I also got in Natal, might have been easily confounded with it, on account of its exceeding faintness and delicacy.

Humboldt considers that a remarkable light seen in 1509 for forty nights consecutively, in the elevated plains of Mexico, was the zodiacal light. He found a notice of this light in an ancient Aztec MS. preserved in the Royal Library of Paris.

Humboldt proceeds to inquire into the nature of the zodiacal light, and considers “a very compressed annulus of nebulous matter revolving freely in space, between the orbits of Venus and Mars, as the material cause” of it. Coming to more modern times, Sir J. Herschel thinks it is “that medium which resists the motion of comets, loaded, perhaps, with millions of tails of these bodies.” Still later, the idea is that it consists of myriads of small meteors, each revolving round the sun in its own path, the light reflected from which impresses itself on our eyes as the zodiacal light. This is the opinion of Prof. Pickering, who, in vol. xix of “The Annals of Harvard College Observatory,” has discussed many observations with his usual acumen.

It would seem certain from the observed angular distance of the apex from the sun that these meteors extend beyond the earth's orbit; and as the light lies in, or very close to, the ecliptic, we must be perpetually cutting through them as we revolve round the sun. Do we see in our atmosphere the falling meteors which have originally formed a portion of the zodiacal light? We are of the opinion this question can only be settled when that of the relation of comets to meteors is settled, and we know what a dubious matter that is in its purely physical aspect.

Dr. Veeder, of New York, considers that the zodiacal light “does not conform to the plane of the earth's orbit, but to that of the equator of the body which it surrounds, which in this case is the sun itself. As viewed from the earth, these coronal extensions are at times foreshortened, and at times opened out, so as to become more plainly visible. In the spring months, the south pole of the sun is inclined toward the earth, so that the latter is almost exactly in the heliocentric zenith of the southern sunspot belt and coronal extension. Consequently, the particles composing this extension are in a direct line between sun and earth, and, shining as they do by reflected light, like the new moon, they become almost invisible. Coincidentally the coronal extension overlying the northern sunspot belt is opened out to its widest extent, and reflects more light earthward than at any other time. Hence, if these extensions become visible as the zodiacal light, the southern edge at this season should be the more sharply defined, and more exactly included within the plane of the ecliptic, because of the lack of illumination described; and the northern edge, on the other hand, should shade off very gradually, departing more widely from the plane of the ecliptic, and this is precisely what has been found to be the case.”

My own observations made at Gibraltar most certainly support this view.* It has also been observed by Cassini and others. Dr. Veeder further observes that it is probable that “these coronal extensions serve as conductors of electrical impulses,” and are therefore connected with the appearance of aurora.

The question of the variability of the zodiacal light has been much discussed. Humboldt says: “I have occasionally been astonished, in the tropical climates of South America, to observe the variable intensity of the zodiacal light. As I passed the nights, during many months, in the open air, on the shores of rivers and llanos, I enjoyed ample opportunities of carefully examining the phenomenon. When the zodiacal light had been most intense, I have observed that it would be perceptibly weakened for a few minutes, until it again suddenly shone forth in full brilliancy. In some few instances I have thought that I could perceive, not exactly a reddish coloration, nor the lower portion darkened in an arc-like form, nor even a scintillation—as Mairan affirms he has observed—but a kind of flickering and wavering of the light.” These rapid apparent changes, however, he thinks, may be partly due to causes acting in the upper strata of our atmosphere.

Olbers convinced himself that “the light is very different in different years, often for several successive years being very bright and diffused, while in other years it is scarcely perceptible.” This, of course, is a different sort of variation from the temporary or momentary changes just mentioned. Some modern observers think it decidedly variable in the way mentioned by Olbers—that is, more brilliant on some occasions than on others. But we must bear in mind two things in considering this question. First: as seen in England the total apparent length of the cone decreases gradually as the season of visibility goes on. Thus, for the evening apparition the length as observed in March and April is nearly always markedly less than when seen in January and February.† Hence, because the length of the cone appears different as seen at dates separated by an interval of (say) a fortnight, it is not necessarily to be inferred that the brilliancy has changed in that interval of time. Second: we all know how after a spell of dull or wet weather an unexpectedly clear night suddenly turns up. On the last occasion of a clear but “poor” night, the zodiacal light perhaps looked poor too. Now, on the very clear evening, it is seen under fine conditions, and naturally the finer and more delicate parts stand out clearly. But this is not variability. We cannot focus our sight on to this delicate object as on a variable star, and the circumstances are such as do not admit of the application of exact photometry to the case. To decide this question we need a regular series of systematic observations made in some clear and serene sky, like that of Peru or the Transvaal, night after night and year after year. Such observations should give, according to a fixed method, the length and breadth; also the brightness, say at certain fixed altitudes, as compared with the Milky Way. It is only from such a record that the question of variability can be settled. Very possibly, changes

*See English Mechanic, No. 1625.

†See observations of Prof. Perera and self in Journal Brit. Ast. Assoc., vol. v, pp. 361, 421.

*Translated from the author's MS. by Henriette Weber, Columbus, O.

in the density of different parts of the zodiacal meteors or cosmic dust may take place from time to time, and consequently, changes in brightness. But I do not think that so far they have been fairly proved.

Some observers have noted a ruddy tint, but I confess that I have never detected this.

Good observers, like Admiral Smyth, acknowledge many disappointments of not catching it; and to anyone who has not yet seen the light, but wishes to do so, I would offer the following suggestions: Time, middle of January to middle of March; locality, remote from any large town or collections of lights. From some of the breezy commons and downs of Surrey or Sussex, well to the south of the metropolis and free from trees, one can command a grand sweep of sky. Better still if the observer has a sea horizon to the west, for then, provided there is no shipping, he may be absolutely certain that no artificial glare exists. Choose a brilliant evening, such as sometimes comes after heavy rain. There must be no trace whatever of moonlight, which blots out our faint subject. Keep on the lookout, say, from a quarter of an hour after sunset. Do not strain the sight by looking fixedly at a star or in one place. Cast the eye occasionally over the western sky toward the horizon, and with the above circumstances favorable, you should have no difficulty in "catching" the phenomenon and "holding" it, too. I am not quite prepared to say whether nearsighted persons would be handicapped in this search. Possibly spectacles may in some way impede vision in sweeping over a large area of the sky. There must be a slight loss of light, even through one lens only. Personally, I am blessed at present with a long sight, which does not need any assistance in the way of glasses. When

er can hardly hope to detect this or the zodiacal band.—Knowledge.

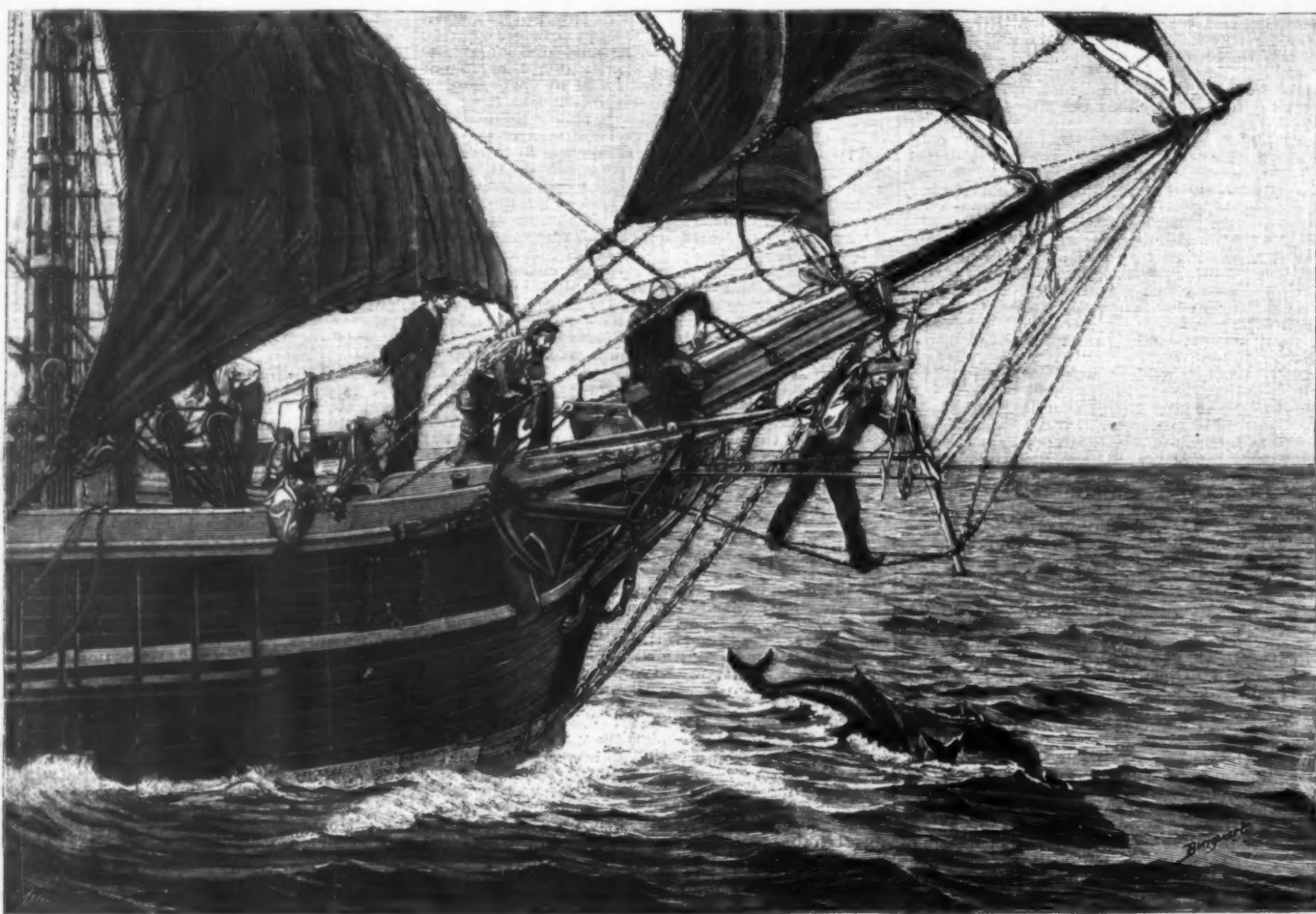
FISHING DURING THE TRIP OF A MERCHANTMAN.

A SLIGHT breeze is blowing. With all its sails set, a three-masted merchantman is plowing its way through the blue waters of the Atlantic. Astern, upon the poop, some of the crew are at work making foot ropes fast to a new mainsail. The captain is striding the deck, casting a glance at the sails, at the steersman and at the sea, and punctuating his promenade with orders: "Keep your eye on the helm!" says he to the steersman. "Tauten the sails there!" exclaims he to the sailors. But see yonder, in the distance, those black objects that are leaping upon the sea and marking their passage with a streak of foam! "Aha! they are porpoises! Boatswain, get out your harpoon, quick! And the rest of you there, come to the fore-castle!" At the captain's exclamation every one raises his head, the cook comes out of his galley, the cabin boy leaves his table utensils in confusion, and all run to the fore-castle. The harpoon is provided with its line and handed to Loic, the most expert of the crew in this sort of fishing. Loic climbs down beneath the bowsprit, and here, his feet firmly planted upon the backstays, his left hand grasping the martingale, and his right brandishing the harpoon, he waits.

In the distance, the porpoises tack about and point their noses toward the ship, and then, turning in the opposite direction, put the patience of the fishermen to a severe test. Loic whistles in order to attract them. Finally, three of them separate themselves from the

more, and then betraying his presence by his fin. On board, he is being watched, in order to see if he will notice the bait. Finally, the odor of the pork attracts him. He pounces upon it, rubs his nose against it in order to ascertain the nature of the thing, turns about suspiciously, makes a point seaward, then suddenly returns, and, his resolution having been taken, turns upon his side, opens his jaws and swallows the bait. Then the hook operates, and the shark begins his dance. His formidable bounds make the stern of the ship tremble amid splashes of foam. The line is paid out a little, and then, when the motions of the shark become slower, the ship proceeds smoothly. Now that he is taken, and well taken, there is nothing to be done but tow him along for a few hours, and with the eight knots that the vessel is making he will soon be mastered.

The next morning, before washing, the captain comes to take a glance. "He can be hauled in now; the old fellow is half dead. Pull in the line to see!" says he. The line is pulled in, and the shark no longer gives any sign of life. It is the moment to take him on board. The brigantine is brailled up and the sheets of the main boom are secured. A winding tackle coming from the mizzen mast is attached to a strong ring of cordage surrounding the main boom, and to the latter is hooked a pulley block through which the line is passed. Then all hands begin to haul, and the shark comes under the taffrail. "Hoist away, my hearties!" The head now comes out of the water, and gradually the body makes its appearance. Sometimes the shark seems to take a new lease of life, and lashes the water with furious blows of his tail. In such a case, he is submerged again. Master Shark this time does not budge. A



PORPOISE FISHING.

once seen, it is comparatively easy to see it again another night, as we then know what sort of a thing it is we are looking for.

It is curious that the zodiacal light has not been seen during a total eclipse of the sun, and it would therefore seem that its light is decidedly inferior to that of the corona. At the same time, in such a consideration one must not omit to take account of the vast area of illuminated earth and sky which surrounds the moon's shadow cone. The darkness of an eclipse is not that of night.

Would an observer from Neptune, supposing he could do without any atmosphere himself, see the sun as a "nebulous star," with the zodiacal light extending on either side like a delicate comet? Very probably—with many a comet plowing through it, which our own atmospheric veil prevents us by its brilliant glare from seeing. Take as an instance the comet seen close against the sun during the total solar eclipse visible in Egypt in 1882.

There are two other phenomena connected with the zodiacal light, viz., the gegenschein, or counter glow, and the zodiacal band. The first is a faint patch of light seen very nearly opposite the sun's place; the other is a prolongation of the zodiacal light to the gegenschein. Both these are excessively delicate phenomena and require the finest sight and sky. Although I consider I have a good eye, I have never seen either. Even Prof. Pickering can only say that "the evidence for the actual existence of some light opposite the sun becomes tolerably strong." Still, there can be but little doubt of the existence of the gegenschein from the observations of Brorsen, Schmidt, Heis, Backhouse, Lewis, Barnard and others. But the ordinary observ-

group and come direct for the ship, to which they are attracted by its copper shining in the sun.

"Attention, Loic! there they are!" and the three cetaceans pass by as quick as a flash in leaping at a couple of yards from the vessel's stem. Loic's uplifted arm shoots forward like a released spring, and one of the porpoises, pierced through and through by the harpoon, struggles at the end of the line and makes desperate efforts to escape in tingling the blue water of the sea with its blood. "There he is!" cries Loic in regaining the fore-castle.

The animal is allowed to struggle and exhaust itself for a moment, and is then gently hauled up alongside, where a line with a slip noose is made fast to its tail, so that it may be lifted on board by means of a capstan. From the fore-castle it is sent to the deck, where the harpoon is removed, and it becomes the temporary property of the cook. Under his expert hand, the porpoise is converted into savory steaks and into huge meat pies that will somewhat vary the mess of pork and beans and hardtack and salt mackerel that forms the basis of the food of the crew of merchantmen.

Shark Fishing.—A shark has been following the ship for a couple of days, awaiting some windfall or other, perhaps the fall of a man from a mast. Its proximity is annoying, and, although the catch is not worth much, an endeavor is to be made to capture it. At the captain's order, the boatswain goes to get a huge hook provided with a chain six feet in length used for this sort of fishing. A rope is attached to this, and the hook having been baited with pork, the whole is trailed astern. Master Shark is always on hand, disporting in the blue water, swimming around the ship, passing under the keel, sometimes disappearing for an hour or

strong slip noose is passed under the caudal fins, the main boom is braced leeward, and the end of the line is hauled by hand, and guided by pulleys to the capstan upon the fore-castle. Then all hands heave at the capstan until the shark is hauled up and laid upon the poop. From there it is dragged to the deck.

There is often a terrible awakening. Then, beware of the blows of the tail and especially of the snapping of the teeth. The animal struggles in opening and closing its formidable jaws with a sharp click, while its tail pounds the deck planks. The men, armed with axes, then attack it and aim especially at the head and tail. Finally, cut and slashed, the shark no longer budges. A few slices of its coriaceous and oily flesh are set aside for the crew, while the captain reserves for himself the vertebral column, which, once arranged and a ramrod inserted in the interior, will serve as a cane, and, at all events, as a trophy. As for the remains, these, thrown overboard, will regale the bonitas and other fishes.

Capture of Albatrosses.—The capture of the albatross, like that of the shark, is, upon the whole, merely a pastime, its oily flesh, smelling like fish, not proving a very agreeable and delicate food. The albatross furnishes the pipes and tobacco pouches of merchantmen sailors. It is also a sort of certificate of the passage of the Cape.

The process of capturing the bird is as follows: To the end of a strong line is fastened a hook of the size of those used in trailing for tunny. This hook is carefully concealed in a piece of thin canvas cut into the form of a fish, or is baited with some sort of detritus or other, and the whole is thrown into the sea. The albatross, which is voracious by nature, never fails, whenever it

sees the bait, to pounce upon it. As soon as it finds the hook fastened in its bill, it spreads its wings and flies away in endeavoring to free itself by violent struggles. If other albatrosses or frigate birds chance to be in its vicinity, they take flight with strident cries in describing circles around the prisoner and in seeming to seek a method of delivering him. A slight pull is given upon the line, and, when the bird is of large size, two men are none too many for the work of landing it upon the deck of the vessel. Once on board, it only remains to kill it. Some put it to death by thrusting a strong sail needle into its skull—a cruel process that has the drawback of not being followed by an immediate result. Others strike it upon the neck with a club. The albatross is not a very handsome bird, and it is remarkable only by the huge size of its wings, the spread of which sometimes reaches twelve and even fourteen feet in adult individuals.—*L'Illustration*.

DREAMS.*

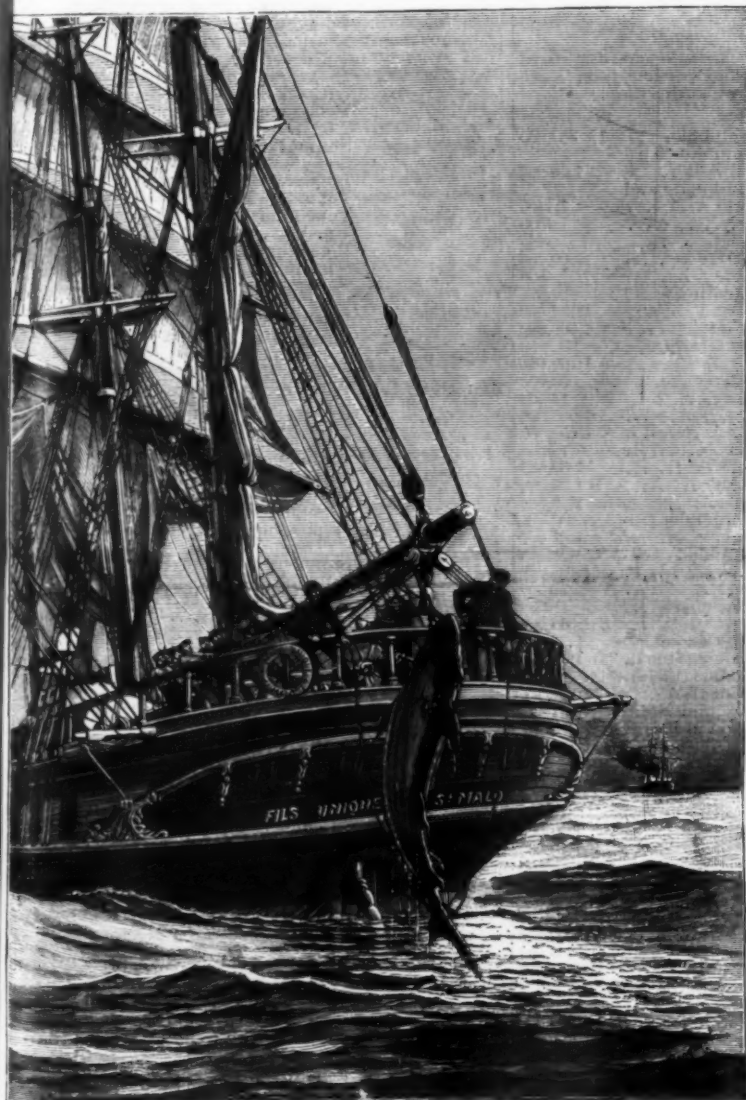
At the psychological congress last year, Dr. J. Mourly Vold, of Christiania, reported some experiments which he had undertaken with regard to the artificial stimulation of visual elements in dreams. The subjects included a large number of persons of different ages, sexes and classes, but were mostly adults of an intellectual type above the average; all those selected were good dreamers. Dr. Vold arranged

original or with some modification; this transformation often occurred in the dream itself. The color exerted an influence independent of the other factors, and this proved the point of greatest interest in the results. When the given objects were black or white (with complementary background) the dreams in many instances exhibited recurring contrasts of light and shade. Often the object reappeared (with considerable change of form) in the same color as shown; or some other object appeared in the given color, which might be a very unusual one for it to take; in this case, either the color of the background reappeared also, or no background was discerned. In experiments with colors other than black and white, the given color also tended to reappear; this was especially the case with red; the color might recur in the same tone, saturation and brightness as in the given object, or it might appear modified in these respects; or, such a modification might take place in the course of the dream, as in the case of modifications of form.

The author concludes from these experiments that the visual apparatus immediately before awakening reproduces to a certain extent the condition present at the time of falling asleep; but that the original associations of form, size, color and abstract representation are broken up, and new syntheses constructed in their stead. In these new syntheses the common visual forms, or abstract representations of daily life, are apt to become associated with the colors or outlines

most vivid; for, unless they result in our awakening, there is no associative element in waking consciousness capable of recalling them. Even those dreams which we do recall have usually so slender an associative element that they are speedily forgotten, unless we take special pains to impress them upon the memory by writing them down or rehearsing them soon after waking.

The present writer would suggest that more attention be paid, in the study of dreams, to determining the normal visualizing power of the individual. It is well known that some persons habitually "visualize" their visual memories (i. e., represent them in the form and color of the original); while others, including those more accustomed to abstract thinking, are lacking in this power, and substitute words or other symbolism for the visual picture. The same is true to some extent of sounds and other classes of sense memories. In sleep, where outer stimulation is practically wanting, central images play the chief rôle, and in the absence from consciousness of more vivid presentations are mistaken by the subject for primary sense impressions. It would seem, then, that there ought to be a broad distinction of some sort between the dreams of the visualizing and symbolizing types of individuals. Whether good visualizers are better dreamers, or whether their dreams are merely of a different character from those of symbolizers, remains to be seen. But certainly the question is well worth investigating.



SHARK FISHING.



CAPTURE OF AN ALBATROSS.

the experiments as follows: To each of his subjects he sent, from time to time, a package containing figures of animals, well-known objects, etc., cut out of white paper, or some striking colored object—a flower, coin, etc. The package was only opened after the subject was in bed. The contents were then displayed on a black background, and scrutinized closely for a considerable time—usually from two to ten minutes—without intermission; in some cases for half an hour or more, interspersed with periods of rest. The light was then put out, and the eyes closed. In the morning, immediately on awaking, the subject wrote a report of his dreams, together with the conditions of fatigue the night before, length of sleep, etc. Prof. Vold supplemented these reports, when it seemed desirable, by verbal questionings. Some three hundred separate tests of this nature were made.

On examining the results, it was found that the character of the dreams depended on a number of distinct factors, such as the quietness and unevenfulness of the preceding evening, but that it did not depend (so far as could be discovered) on the specific time of experimentation or of awakening, nor on the obtaining of after-images from the given objects. The size, form and color of the objects were rarely all reproduced together, but one or two of these conditions often reappeared in the dreams. The form and size of the object were frequently reproduced, either as in the

of objects which affect the organ of vision just before the beginning of sleep. Some such theory seems necessary to account for the facts brought out in these experiments.

In a note in the *Revue Philosophique*, M. E. Goblot speaks of the connection between dreams and the act of awakening. He urges the view that dreams which we remember are those which accompany the latter state. The passage from sleep to wakefulness, like that from wakefulness to sleep, is not an instantaneous process; it occupies at least an appreciable time. The dreams which we are able to remember afterward are those that belong to this period of transition; and this fact, the author insists, is more than a mere coincidence. When we analyze a remembered dream, we find in its last stages always some elements of external sensation, which gradually (or quickly) unfold into the conditions of normal waking life. All the organs of sense and movement do not wake at the same time; and to this is due the transition period just mentioned. It is only the dreams of this period—in which some of the conscious elements are those of sleep, while others belong to waking life—that we are able to connect through memory with after-consciousness; and the memory connection is due to precisely this association of elements of waking consciousness with the dream elements. This is the reason, says M. Goblot, why we do not remember those dreams occurring early in the night, in which we talk, cry out, gesticulate, or walk, though such dreams can scarcely fail to have been

So far as I know, no attempt has yet been made to gather data bearing on this point.

SOLUTION FOR PREPARING COLOR SENSITIVE PLATES.

H. VOLLENBRUCH, in *Deutsche Photographen Zeitung*, maintains that plates sensitized with erythrosin silver citrate are not only more sensitive to color impressions, but also have better keeping qualities than ordinary erythrosin bathed plates.

For depression of the over-active blue rays he recommends the addition of picric acid to the coloring solution. The picric acid erythrosin silver citrate ammonia solution is prepared as follows:

Solution I.

Citrate of potassa	1 grm.
Distilled water	10 c. c.

Solution II.

Silver nitrate	1 gr.
Distilled water	10 c. c.

Both solutions are mixed and a white precipitate is formed which is allowed to subside. The clear supernatant liquid is poured off carefully, precipitate washed with water, allowed again to subside, and the wash water again decanted. This process is repeated two or three times. Finally a large bulk of water (30 cc.m.) is

* The American Naturalist.

added to the precipitate and well shaken; 5 c. c. of this is reserved, the remainder is treated to ammonia, drop by drop, until the precipitate is redissolved. Now add the 5 c. c. of reserved solution and shake the whole until every particle is dissolved. Then make up the solution to 50 c. c. and filter; this forms Solution III.

Solution IV.

Distilled water 300 c.c.
Pure erythrosin 1 gr.

Under lamp light the 30 c.c. of Solution III. are poured slowly with repeated shaking in Solution IV, by which the originally beautiful red is converted into a dirty turbid bluish red somewhat viscid fluid; add—

Solution V.

Picric acid 4 grms.
Absolute alcohol 30 c.c.

Shake well and add to the whole 33 c.c. ammonia (specific gravity 0.91), wherewith the beautiful red color is restored.

After the filtration call this Solution VI. This solution keeps well. The slight deposit formed is redissolved on shaking.

The plates are sensitized as follows: The plate to be sensitized is first laid in a tray of distilled water for two or three minutes, then bathed in a mixture of 1 c.c. ammonia for one minute and finally for two minutes in a bath composed of the following:

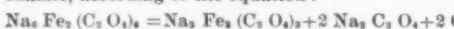
Color Solution VI 10 c.c.
Distilled water 300 c.c.

The plate is well drained and dried in a perfectly dark room. These plates keep well for several months.—American Journal of Photography.

THE PRINTING-OUT PLATINOTYPE PROCESS.

THE statement made by Mr. Cembrano in his presidential speech before the convention at Yarmouth, England, to the effect that "a paper is much needed possessing the ease and simplicity of manipulation, permanency of results and beauty in quality of platinotype, combined with the certainty in printing of what are commonly called printing-out papers," naturally suggests to one the printing-out platinotype process, which seems to have been much neglected in England.

This process was suggested by Pizzighelli in 1887, and differs from the other platinotype processes in that the developer is in the sensitizing solution. As a rule, sodium ferric oxalate is used, which, by exposure to light, is reduced to sodium ferrous oxalate and sodium oxalate, according to the equation:



Sodium ferric oxalate occurs in fairly large green crystals, which are perfectly stable in the dark, and are easily soluble in water (about one in two), and when spread on paper it gives a yellowish green film.

As damp is necessary for the full development of the image, it is necessary to expose it to aqueous vapor before printing; otherwise the printing is precisely the same as for any other of the platinotype papers. The best way of dampening the paper is to fill a developing dish with warm water, and just hold the paper for about three minutes in summer and one and a half minutes in winter, film face downward over the same. It is frequently recommended to breathe on the paper while it is in the printing frame; but this is hardly to be commended, for the simple reason that part of the paper near the middle of the frame, as a rule, gets less moisture, and therefore shows fainter in the finished print; further than that, the negative, unless covered with a piece of plain paper, also becomes moist and absorbs some of the platinum or iron salts, and thus stains are caused which are extremely difficult to eradicate.

For this process there is no doubt that Rives or Saxe papers are the best, though Whatman's or Creswick papers may be used.

The sensitizing salts should be made up into the form of stock solutions. The sodium ferric oxalate solution should be made by dissolving, by the aid of a gentle heat, 240 grains in 1 ounce of distilled water, and the solution filtered and labeled "The Iron Solution."

The chloro-platinite of potash may be dissolved in the proportion of 1:6, or a 15 grain tube in 90 minims of distilled water.

Besides these will be required a ten per cent. solution of sodio-chloride of platinum, which is added to the sensitizing solution to give brilliancy or greater contrast, and is especially useful for thin, flat negatives.

A solution of gum arabic must also be used, and 1 ounce of the best white gum arabic in lumps should be dissolved by constant stirring in 2 ounces of distilled water, and then filtered through nainsook, using pressure if necessary.

The sensitizing solution itself is prepared by mixing, preferably in a flat dish or saucer:

Chloro-platinite solution 116 minims
Iron solution 120 "
Gum arabic 116 "

The above quantity is sufficient for 480 square inches of paper. The solution should be brushed over the paper with a broad, flat brush, not too soft, and then the marks evened out with another till it has lost all glaze, then quickly dried, and the process of drying should not take more than half an hour. Great care should be exercised in the choice of the brushes. A soft camel's hair brush will mop up too much solution, while a hard brush is apt to cause marks in the sensitizing.

Sepia-toned pictures may be obtained by the addition of palladium or mercury salts to the sensitizers, but the results obtained by these are by no means satisfactory, nor is there any good method of obtaining sepia tones direct by this process.

Mercury gives, as a rule, yellowish whites, and the tones are not even, that is to say, the high lights may be sepia, the half-tones gray, and the shadows black. With palladium the difficulty is to keep the paper, and it must be printed out dry and then developed, or else variations in tone and general reduction may ensue.

A formula strongly recommended by Watzek for the mercurial paper is:

Sodium ferric oxalate solution 168 minims
Potassium chloro-platinite solution 100 "
Potassium chlorate solution 4 drops
Mercuric chloride solution 84 minims

All these solutions should be saturated. It will be found necessary, if this be used, to give the raw paper at least two coatings of plain two per cent. arrowroot size; but it is preferable to use the gum arabic solution in about the same proportion as suggested for the black paper, and also to replace the chlorate of potassa by a like quantity of sodio-chloride of platinum, which keeps the white purer.

For the palladium paper the following may be used:

Iron solution 120 minims
Chloro-platinite solution 80 "
Potassium-chloride of palladium solution (1:8) 20 "
Gum arabic solution 116 "

It must not be forgotten that this paper must be absolutely dry during printing, and only developed by steam afterward.

The subsequent treatment of these prints is precisely the same as for ordinary platinotype, namely, the use of the three acid clearing baths, and then well washing. The process is not a difficult one. The chief difficulty is the drying.—British Journal of Photography.

DELICACY OF VARIOUS REACTIONS FOR METALS.*

By Dr. B. NEUMANN.

THE following table, in its rearranged and improved form, is the result of the author's personal experience and comparison with well known authorities:

Metal.	Reagent.	Sensitiveness.
Arsenic.....	Hydrogen Sulphide.....	1:3,600,000
(as arsenious acid)	Sodium Sulphite and Stannous Chloride.....	1:20,000
	Sodium Thiosulphate and Hydrochloric Acid.....	1:1400
	Lime Water.....	1:4000
	Cupric Sulphate.....	1:8640
	Argentio Nitrate.....	1:200,000
	Electrolysis.....	1:1500
	Electrolysis (with Fe and Cu).....	1:133,000
	Marsh's Test (Mohr).....	1:500,000
	Marsh's Test (Devergie, Otto).....	1:100,000
	Bettendorff's Test.....	1:1,000,000
	Fleitmann's.....	1:5000
	Gutzeit's.....	1:1,000,000
	Reinsch's.....	1:250,000
	Fresenius-Babo.....	1:5000
	Zwenger's.....	1:50,000
Antimony.....	Zinc (Fresenius).....	1:30,000
	Zinc (Rideal).....	1:20,000
	Hydrogen Sulphide (Rideal).....	1:41,000
	Hydrogen Sulphide (Neumann).....	1:100,000
	Lime Water.....	1:1200
	Potassium Carbonate.....	1:2000
	Electrolysis.....	1:1,500,000
	Electrolysis (by Fe and Pt).....	1:83,000
Bismuth.....	Potassium Iodide (Stone).....	1:1,000,000
	Potassium Iodide (Field).....	1:1,600,000
	Hydrogen Dioxide.....	1:190,000
	Tartaric Acid and Stannous Chloride in K O H Solution.....	1:210,000
	Potassium Cinchonylhydroiodide.....	1:1,000,000
Cadmium.....	Sodium Sulphide.....	1:250,000
	Potassium Ferrocyanide.....	1:10,000
	Sodium Hydrate.....	1:50,000
	Sodium Carbonate.....	1:20,000
Cobalt.....	Potassium Ferrocyanide.....	1:60,000
	Potassium Cyanide and Ammonio Sulphide.....	1:50,000
	Sodium Sulphocyanate.....	1:2000
	Potassium Xanthogenate.....	1:100,000
	Ammonia.....	1:1,000,000
	Sodium Hydrate.....	1:10,000
Copper.....	Potassium Ferrocyanide (Wagner).....	1:200,000
	Potassium Ferrocyanide (Cooper).....	1:4,000,000
	Potassium Ferrocyanide (Neumann).....	1:250,000
	Ammonia (Wagner).....	1:25,000
	Ammonia (Neumann).....	1:50,000
	Ammonia (Will).....	1:100,000
	Ammonia (Cooper).....	1:1,000,000
	Potassium Xanthogenate (Wagner).....	1:900,000
	Potassium Xanthogenate (Schwarz).....	1:1,000,000
	Hydrogen Sulphide (Cooper).....	1:15,660,000
	Hydrogen Sulphide (Neumann).....	1:4,150,000
	Potassium Arsenite.....	1:10,000
	Sodium Sulphide.....	1:700,000
	Sodium Hydrate.....	1:30,000
	Potassium Carbonate.....	1:14,000
	Hydrobromic Acid (Neumann).....	1:10,000
	Hydrobromic Acid (Sabatier).....	1:10,000,000
	Hydrobromic Acid (Endemann and Prochazka).....	1:100,000
	Sodium Sulphite and Pyrogallol.....	1:3,000,000
	Electrolysis (with Iron).....	1:15,000
	Electrolysis (with Pt and Zn).....	1:4000
	Electrolysis (with Pt and Br).....	1:1,000,000
	Guaiaec Tincture and Alkali Chloride.....	1:10,000
	Guaiaec Tincture+HCN.....	1:500,000
	Guaiaec Tincture Alcohol+HCN.....	1:10,000,000

* Pharm. Zeitung, xiii, page 120, (Drug Topics.)

Metal.	Reagent.	Sensitiveness.
Ferric Oxide.....	Potassium Ferrocyanide.....	1:500,000
	Potassium Sulphocyanate.....	1:1,000,000
	Ammonia.....	1:800,000
	Ammonia and Thioglycolic Acid.....	1:200,000
Ferric Oxide.....	Extract Logwood.....	1:15,000,000
	Tannic Acid.....	1:300,000
	Salicylic Acid (Smith).....	1:32,000
	Salicylic Acid (Almén).....	1:100,000
	Ammonium Sulphide.....	1:2000
	Sodium Sulphide.....	1:700,000
Ferrous Oxide.....	Potassium Ferrocyanide.....	1:440,000
	Ammonia.....	1:500,000
	Oxalic Acid.....	1:5000
	Sulphuric and Nitric Acids.....	1:300,000
	Tannic Acid.....	1:440,000
	Sodium Sulphide.....	1:700,000
Gold.....	HCl+Stannous Chloride.....	1:100,000,000
	Aqueous Hydrogen Phosphide.....	1:10,000
	Potassium Sulphocyanate.....	1:10,000
	Stannous Chloride (on Gold Bromide).....	1:1,433,600
Iridium.....	Concentrated H ₂ SO ₄ +K OH.....	1:1,000,000
	Concentrated H ₂ SO ₄ +K OH, and Ammon. Nitrate.....	1:1,000,000
Lead.....	Hydrogen Sulphide (Papenhelm).....	1:100,000
	Potassium Bichromate.....	1:100,000,000
	Hydrogen Sulphide (Cooper).....	1:196,000,000
	Potassium Bichromate (Cooper).....	1:4,000,000
	Potassium Bichromate (Harvey).....	1:3,500,000
	Sulphuric Acid.....	1:40,000
	Sodium Sulphate.....	1:5000
	Potassium Carbonate.....	1:20,000
	Potassium Ferrocyanide.....	1:18,000
	Potassium Iodide (Jeanne).....	1:40,000
	Potassium Iodide (Neumann).....	1:10,000
	Electrolysis.....	1:50,000
	Cochineal Solution.....	1:400,000
	Electrolysis+Cl+HI or H ₂ S.....	1:150,000
Magnesium.....	Ammonia.....	1:8000
	Ammonia and H ₂ PO ₄	1:200,000
Manganese.....	Silver Nitrate and Caustic Soda Solution.....	1:200,000
	Potassium Ferrocyanide.....	1:25,000
	Ammonia.....	1:100,000
	Sodium Sulphide.....	1:500,000
Mercuric Oxide.....	Potassium Iodide.....	1:8000
	Hydrogen Sulphide (Schneider).....	1:200,000
	Hydrogen Sulphide (Vignon).....	1:240,000
	Stannous Chloride (Overbeck).....	1:40,000
	Stannous Chloride (Schneider).....	1:50,000
	Electrolysis.....	1:48,000
	Electrolysis and Cl+KI.....	1:100,000
	Tincture Guaiac.....	1:150,000
	Lime Water.....	1:30,000
	Potassium Ferrocyanide.....	1:1500
	Alkaline Solutions.....	1:6000
Mercurous Oxide.....	Sodium Chloride.....	1:80,000
	Alkaline Solutions.....	1:80,000
	Potassium Carbonate.....	1:7000
Nickel.....	Potassium Xanthogenate.....	1:100,000
	Bromine+KOH.....	1:1,000,000
	Potassium Ferrocyanide.....	1:100,000
	Ammonia.....	1:10,000
	Sodium Sulphide.....	1:1,000,000
	Sodium Hydrate.....	1:10,000
Potassium.....	Sodium Nitrite, Cobalt Chloride and Acetic Acid.....	1:1000
	Platinic Chloride.....	1:205
	Tartaric Acid.....	1:220
Silver.....	Potassium Iodide.....	1:4000
	Potassium Chromate.....	1:10,000
	Potassium Arsenate.....	1:10,000
	Hydrogen Sulphide.....	1:35,000
	Sodium Chloride.....	1:24,000
	Potassium Xanthogenate.....	1:40,000
	Potassium Ferrocyanide.....	1:3300
	Electrolysis, Chlorine and Pyrogallol.....	1:200,000
Tin.....	Bruce.....	1:20,000
Zinc.....	Potassium Ferrocyanide (Mylus).....	1:1,000,000
	Potassium Ferrocyanide (Jordis).....	1:3,000,000
	Ammonia.....	1:6000
	Ammonium Carbonate.....	1:8000
	Ammonium Sulphide (Aarlandt).....	1:2860
	Ammonium Sulphide (Cooper).....	1:2,500,000
	Ammonium Sulphide (Jordis).....	1:50,000
	Ammonium Sulphide (Neumann).....	1:100,000

Since it is difficult to get flues quite airtight and smooth enough not to interfere with the cleaning, and in order to prevent partial stoppages which may be caused by materials falling down during building, it has been proposed to build the flues directly of stones provided with hollows of the desired sections. In the stones of Zumbroich, of Hagen in Westphalia, made of cement, beton, etc., these hollow channels are arranged eccentrically. Three of the walls have the same thickness, the fourth is thicker. On the upper thick surface a step is formed. If, then, the stones are fitted into one another so that the thicker sides lie alternately right and left, the inner channel will be straight and the stones will rest firmly on one another.

ENGINEERING NOTES.

The first German town to adopt the motor car for cab service is Stuttgart. Rubber tired cabs run there beside the usual horse cab; they are driven by a four horse power motor, which makes them quicker than the ordinary cab, especially for long distances and country driving, and the charge is the same as for ordinary cabs.—Uhländ's Wochenschrift.

It is stated the Chilean government has decided to appropriate \$500,000 for encouraging the development of iron and steel foundries in that country. One hundred and twenty thousand dollars will be given to an American syndicate as a bonus for establishing an iron foundry, and the residue of the sum mentioned is to be similarly distributed. Government reports say that iron ore exists in abundance in Chile.

H. C. Fairbanks, of Sibley College, while constructing a gas engine, observed a singular though probably not exceptional phenomenon which, so far as known, has not been previously described. The machine exhibited a great loss of heater efficiency, which was unaccounted for and was not affected by any changes made in the process of repair. Finally it was suspected that the conductivity of the metal of the cast iron "fire pot" had been impaired by oxidation or otherwise, and it was replaced by a new one. The engine at once started off at full power and regained its original efficiency.

The Engineering News says: "Brazilian railways, says a Paris news item, are to be farmed out to an English-French-German syndicate. A provisional contract has been signed between the Brazilian government and the Rothschild Frères, the Discount Bank of Berlin and the Comptoir d'Escompte de Paris. A company is to be formed to take over the administration of the Brazilian railways. The capital will be \$40,000,000, half of which will be taken by the English group and one-quarter each by the French and Germans. One of the conditions is that this capital is to remain in Europe for two years, and numerous sinecure offices on the railways will be suppressed and abuses in administration reformed."

The authorities of the Madras Presidency have decided to invite proposals for the utilization of the water power that is at present running to waste in the flow from the Periyon Lake, says The Trade Journals Review. There are immense industrial possibilities in the scheme. The fall is approximately 800 feet, and for nine months of the year the flow varies from 500 to 1,100 cubic feet per second, the lowest average being equal to a force of 30,000 horse power. The Indian government is prepared to rent any part of the whole supply at a certain rate per cubic foot per second, so that small factories could be established; and as a large quantity of jute and other natural products abound at Madras, there is a splendid opening for extensive mills for its preparation into finished goods. The government intends to give the first year of the concession free, charging only a fifth for the second year and continuing to add a fifth for each successive year of the lease. There is also the possibility of power transmission to considerable distances. As this has already been done in other parts of the world, there is no reason why it should not be financially successful in India.

That galvanized sheets which are made of steel, with the oxide formed in rolling removed, and then coated with spelter, are not more generally used in boiler or tank works is because the advantages thereof are not sufficiently understood, says the American Boiler-maker. The extreme cheapness of steel plate and improvement in manipulating same have led to the substitution of steel plate stacks and chimneys for brick. It is, however, well for boiler-makers to remember that the action of moisture, especially when impregnated with sulphur arising from soft coal, has a destructive influence on steel plates, rusting rapidly, particularly in the lighter gages. This may be delayed by frequent painting or varnishing. The coating of spelter on steel sheets is impervious to moisture, and therefore the life of the metal is preserved indefinitely, especially where it may be painted with the ordinary commercial stack or boiler paints. We would remind boiler-makers that unless they call the attention of their customers to this fact, they will find a large and profitable part of their business leaving them, on account of the short life of the ordinary steel stack as now made, because the first cost of the brick chimneys will be of less importance than the inconvenience and cost of having to replace a steel stack or chimney.

The following table gives the railway mileage of the five great continents of the world, says The Engineer. The first column represents the totals in 1895, the second in 1891, and the third shows the increase in the four years:

	1895.	1891.	Increase.
Europe.....	155,284	141,552	13,732
Asia.....	26,890	23,023	4,867
Africa.....	8,169	6,522	1,647
America.....	229,722	212,734	16,988
Australia.....	13,888	12,322	1,566
The world....	433,953	395,143	38,810

The percentage of increase in mileage was greater in Africa than in any other continent; but this great percentage was only 1,647 miles. The South African Republic led in new construction, building 491 of its 616 miles between 1891 and 1895. Cape Colony followed, and it has more railroads than any other African country, followed by the French possessions Algiers and Tunis. Egypt made an addition of 31 per cent. to its mileage in the four years in question, as did also the Orange Free State. Just about half of the African mileage is in the comparatively small area of South Africa. Among European countries the rank in mileage is as follows: Germany, France, Russia, Great Britain and Austria. No other country has so much as 10,000 miles. The largest increase in mileage since 1891 has been in Russia—4,146 miles and 21.4 per cent. No other country in Europe added half so much to its mileage. But Spain gained 18.3 per cent. and Sweden 17.7 per cent. The gains in France, Germany, and Austria-Hungary were from 6½ to 7 per cent.

MISCELLANEOUS NOTES.

Salt has just been put in the allowance of food which the British government gives its sailors, though other condiments were allowed in the rations. When "salt horse" was the main staple of diet there was no need of it, but although this was changed on men-of-war long ago, the Admiralty has only recently discovered that the men have no salt. They have been obliged to buy it out of their wages for years.

Since 1797 there have been 1,100 theater fires with 10,000 fatalities, according to Mr. Sachs' "Fires and Public Entertainments," just published. Of these, 462 took place in the United States, 139 in Great Britain, and 101 in Germany, France having nearly the same number. London has had 35 fires and Paris 28. Out of 343 theaters destroyed by fire, one-half were burned within ten years after they were constructed, forty of them within the first year.

Regarding the formation of petroleum, Prof. Dr. C. Engler, an authority in this field, has become convinced, in a recent voyage to the Orient, of the correctness of his theory advanced about thirty years ago, viz., that petroleum has formed from the remains of an extinct fauna. On the other hand, the results of investigations by Cloez supported Mendeleeff's hypothesis of the formation of the petroleum by the action of water and salt solutions on carbide of iron, for Cloez obtained, by the action of water on crude iron and on magnesian iron a number of hydrocarbons of the same combination as that of earth oil.

Endless are the inventions which the bicycle has been the means of stimulating. We notice that a Glasgow inventor has patented an improved method of impregnating materials, such as chrome tanned leather or cotton, canvas or like fabrics, with a solution of India rubber, more especially the materials for use in the construction of pneumatic tires. The material, when dry and warm, is immersed in a bath of naphtha, benzine or other solvent until thoroughly saturated. This, when drained of unnecessary excess, is placed in a warm bath of India rubber, gutta percha or other solution with which the material is to be impregnated, the solution being at from 100° to 110° F. The material is then dried and treated to remove unnecessary surface deposit. The patentee does not say in what respect his materials treated in this manner will be superior to existing manufactures of this kind.

An excellent movement in behalf of ascertaining the value of different varieties of native stone found in California for structural purposes has been undertaken by Prof. Lawson, of the department of geology in the University of California, at Berkeley. From quarries or outcrops where quarries are possible, and where the stone is fairly uniform, it is proposed to secure two blocks of stone, one a twelve inch cube dressed differently on different faces to show the qualities of the stone, and a four inch cube, similarly dressed, for preservation in the college. In cases where the rock has ornamental qualities and varies in texture and color, as in the case of marble deposits, several such blocks would be required fairly to represent the prevailing characteristics; and then there may be cases where, owing to special structures, the stone will appear to better advantage in the form of slabs or columns. These specimens, properly cut by skilled operators, are to be made part of the university's permanent economic exhibit, and such a collection will, it is believed, be made of positive practical value in determining the kind of stone best adapted for constructive purposes.

Materials containing natural dyestuffs and tannin are reduced by a firm in Milan by means of sulphites or bisulphites to compounds which are more slightly soluble (with the exception of the products obtained from quebracho, hemlock and pine extracts) than the starting materials, but show a considerably better behavior in dyeing. Concerned are: Yellow wood, fustic, quercitron, hemlock, quebracho and pine. The conversion takes place at a higher temperature and higher pressure. Thus yellow wood extract, when heated from 110° to 115° C. with bisulphite of sodium of 35° B., affords a substance which produces pure yellow shades of great beauty and intensity upon alumina and a chrome mordant. One part of the new compound dyes upon alumina about equally as strong as one and a-half parts of pure yellow wood extract. A similar proportion is shown by fustic and quercitron extracts. From quebracho, hemlock and pine extracts, however, upon heating with bisulphite of sodium from 100° to 150° C. products are obtained which are readily and entirely soluble even in cold water. Considering the high demands in the quick tanning processes for pure and clearly soluble tanning extracts, the new products are regarded with great interest.

A unique idea receives practical realization at the great dyeing plant of Messrs. Brownlow & Stansfield, Leeds, England, in a new and peculiar method by which cloth gets a different shade on each side, the necessity of an extra lining being thus done away with. In this process the cloth or material to be treated is first dyed through in any shade of color in the usual manner, then finished by the ordinary processes, after which it is taken to a printing machine provided with a roller engraved all over uniformly with diagonal lines cut deeply and running in one direction over its surface, with diagonal lines cut less deeply and running in the other direction. This roller dips into a bath of thickened color of the required shade and carries it up to the cloth, which is by means of other rollers brought into contact with the dyeing roller; the latter, in order to prevent the color penetrating too deeply, is carefully adjusted in its pressure, and thus the second color is kept from going more than half way through the piece. Serew levers are also arranged upon each end of the roller for adjusting the pressure. After the second color has been applied the cloth is steamed and finished in the ordinary way.

The tensile strength of copper is 33,079 pounds at 122 degrees Fah.; 32,187 pounds at 212 degrees; 30,872 pounds at 302 degrees; 29,981 pounds at 482 degrees; 25,420 pounds at 545 degrees; 23,302 pounds at 602 degrees; and 11,054 pounds at 1,010 degrees Fah. When alloyed with tin in the proportion of 8 of the former to 1 of the latter, the tensile strength is 50,000 pounds per square inch of section.

SELECTED FORMULÆ.

Metal for Locomotive Cylinders.—At a recent convention of the American Railway Master Mechanics' Association one of the members gave a mixture used in making metal for locomotive cylinders, valves, and valve seats. This mixture consists of 20 per cent. steel castings, old steel springs, etc., 20 per cent. No. 2 coke iron, and 60 per cent. scrap. From this it was stated a good solid metal could be obtained, the castings being free from honeycombing, and finishing better than the ordinary cast iron mixture, over which it had the advantage of 24 per cent. greater strength. Its constituents are: Silicon, 1.51; manganese, 0.33; phosphorus, 0.65; sulphur, 0.068; combined carbon, 0.62; graphite, 2.45.

Foundry Facings.—The description of facing sand, which Mr. H. F. Frohman gives in the paper which he read before the Western Foundrymen's Association, is just about as clear an explanation as could be desired by any one seeking to know the rationale of certain operations in the ironfounder's craft. It is free of all chemical terminology, which too frequently serves to confuse and obscure simple phenomena. It explains in the simplest language exactly that which working foundrymen want to know. He tells how the most common facing to mix with the sand is coal dust, and gives the reason for it. The crushed coal is mixed with the sand which is nearest to the surface of the mould, in order to break up the particles of sand, so that when the molten metal comes into the mould it does not fuse the sand to a hard mass similar to glass, but allows the coal to burn away, thus leaving the sand in a separated condition, so that when the casting has cooled these separated particles of sand will readily drop off. This can be verified by putting a small quantity of silica sand into a heated vessel so that the temperature will just about fuse the sand. It will melt and run together into a solid mass. There is another reason for the use of coal dust, and that is that it will help materially to vent the mould and allow the gases to escape. Coal dust for facing sand should be made from the best quality of soft or bituminous coal, containing neither slate nor phosphorus, but high in hydrocarbon gases and volatile matter, and the best gas coal makes the best dust for facing. This is the only kind of facing that is mixed with the sand. There are other facings, such as charcoal blacking, but these are either dusted on the mould or applied wet with a brush, as the class of work requires.

Decolorization of Carbolic Acid.—To decolorize the acid the following simple method, which if found reliable is sure to be largely employed, is recommended by the Pharm. Post. For purifying carbolic acid which had already become quite brown-red on account of having been kept in a tin vessel, the receptacle was exposed for a short time to a temperature of 25° C. (77° Fah.), thus causing only a part of the contents to melt. In this state the latter was put into glass funnels and left to stand for ten to twelve days in a room which was likewise kept at the above temperature. Clear white crystals formed from the drippings, which remained unchanged, protected from air and light, while by repeating the same process more clear crystals were obtained from the solidified dark colored mother lye. In this manner 75 to 80 per cent. of clear product is obtained altogether.

Deep Black Writing Ink from Logwood Extract.—Prepare a clear logwood extract solution by dissolving 200 parts of best French logwood extract in 1,000 parts of water by heating in a steam bath, place the solution aside to settle for about eight days and pour off clear from the accumulated deposit. Dissolve 200 logwood extract solution with 500 water, heat in a steam bath to about 90° C. (197° F.) and add drop by drop the following oxidation mixture prepared from 2 dihydrate of potassium, 50 chrome alum and 10 oxalic acid dissolved in 150 water. Maintain the temperature for another half hour at 90° C. (197° F.), dilute with water to 1,000 total weight, add 1 per cent. carbolic acid, and allow to settle two or three days. Then express clear and fill in bottles.

Cementing Glass to Metal.—To glue glass to metal use the paste made by boiling together:

Resin.....	20 parts.
Soda.....	6 "
Potassium silicate.....	2 or 3 "
Water.....	22 "

A froth is obtained. This should be skimmed off and 50 parts of it mixed with 80 parts of plaster of Paris (gypsum).—La Science en Famille.

Cement for Caoutchouc.—The following method of repairing the cracks or fissures in articles of caoutchouc is given in the June number of L'Industrie Textile. First clean the surface of fissure or parts to be united very carefully and apply a cement composed of:

Sulphide of carbon.....	26 parts.
Gutta percha.....	2 "
Caoutchouc.....	4 "
Fish glue.....	1 "

The edges of the rent should be kept together by means of thread and the article left to dry. At the end of from twenty-four to thirty-six hours the binding thread may be removed and the cement which may have squeezed out of the fissure cut away.

Preserving Oil.—The turning rancid of oil is due to a superficial oxidation, which may be avoided by spreading over the oil a film of good whisky; this by its inferior specific weight is kept on the top of the oil, and effectually keeps the air from it. Bottles containing oil should, of course, be corked well, in addition to the above precautions being taken.—La Vie Scientifique.

Blackening Aluminum.—A thoroughly good and practical way of blackening aluminum has until recently been unknown. The following, however, gives very good results: Polish the surface to be blackened with glass paper, then spread on it a thin film of olive oil, and heat slowly on a spirit flame. After awhile the oil boils and takes a golden color. Then lay on another coat of oil, and heat strongly. The golden color becomes brown and soon darkens to an intense black. Let the article cool, wipe off the oil and let dry.—Cosmos.

FRANÇOIS' AIR COMPRESSOR AND ROCK DRILL.

MR. JOSEPH FRANÇOIS, of Seraing, whose name has been long known in connection with air compressing machinery, makes a fine display in the Machinery Hall of the Brussels Exhibition of compressors and rock drills. The former is illustrated by Figs. 4, 5 and 6. A special feature of this arrangement is that the springs controlling the movement of the air inlet valves are governed by a positive motion from the slide valve of the steam cylinder. It will be noticed that the clearance spaces at each end of the cylinder are reduced to insignificant dimensions, thus increasing the effective volume of air compressed with each stroke of the piston. This space is further reduced by the cold water admitted through the inlet valves for absorbing the heat developed during compression. This water flows freely into the cylinder to an amount of about two liters per cubic meter of air compressed. In the illustrations, A is the steam cylinder of the compressor; B is the air cylinder; C, the air inlet valves and the delivery valves; E F, the centers of the levers regulating the action of the springs closing the inlet valves; G is a single lever mounted on E and connected to an extension of the valve rod; H I are double levers

mounted on the shaft, E F; T are the valve springs governed by the levers, H I; K is a connecting rod between H I. The following are some of the leading data of the compressor exhibited:

Diameter of steam cylinder....	12.60 in.
" air cylinder.....	11.81 "
Length of stroke.....	19.69 "
Maximum speed.....	80 revolutions.
Minimum ".....	5 "
Horse power developed with a speed of 60 revolutions per minute and an effective air compression to 71 lb. per square inch.....	25
Weight of air compressed per hour at a speed of 60 revolutions per minute.....	660 lb.

Two types of rock drills are also shown by the same exhibitor, and the smaller of these is illustrated by Figs. 1, 2 and 3, of which the perspective view gives a good idea of the general arrangement and Figs. 2 and 3 longitudinal and transverse sections. The drill is one of the smaller standard series, known as No. 7, because the diameter of its cylinder is 7 centimeters (2.76 in.) The general construction of the drill is that so

well known by the names of the inventors, Dubois and François, but two special features are introduced to lessen the effect of shock on the mechanism at the end of each stroke. At the front end this is effected by means of a small safety cam, N, mounted in a recess on the guide of the piston rod, and of a rubber cushion, P, also in the recess, one end of the cam entering a recess in the rubber, while the other end can act on the spring, R, coupled to the valve, G. When the piston B, strikes against the bottom of the cylinder, the cam is slightly and suddenly moved by a compression of the rubber pad produced by the shock, and the spring being released prevents the valve, G, from closing, and the air pressure immediately checks all further movement. At the opposite end of the cylinder a small auxiliary piston is placed, the rear face of which is constantly under pressure by means of a small passage leading from the valve chest, and, when the piston is driven back at the end of the stroke, the air serves as a cushion. Referring to the reference letters on the section, A is the drill cylinder; B, the piston rod coupling the drill; C, the slide valve; D, D', two pistons of different diameters; E, the valve chamber; F, a lever opening the valve, G, which is the air exhaust; H, the ratchet wheel for turning the drill; J, a guide for supporting the piston rod; L is a feed screw for advance

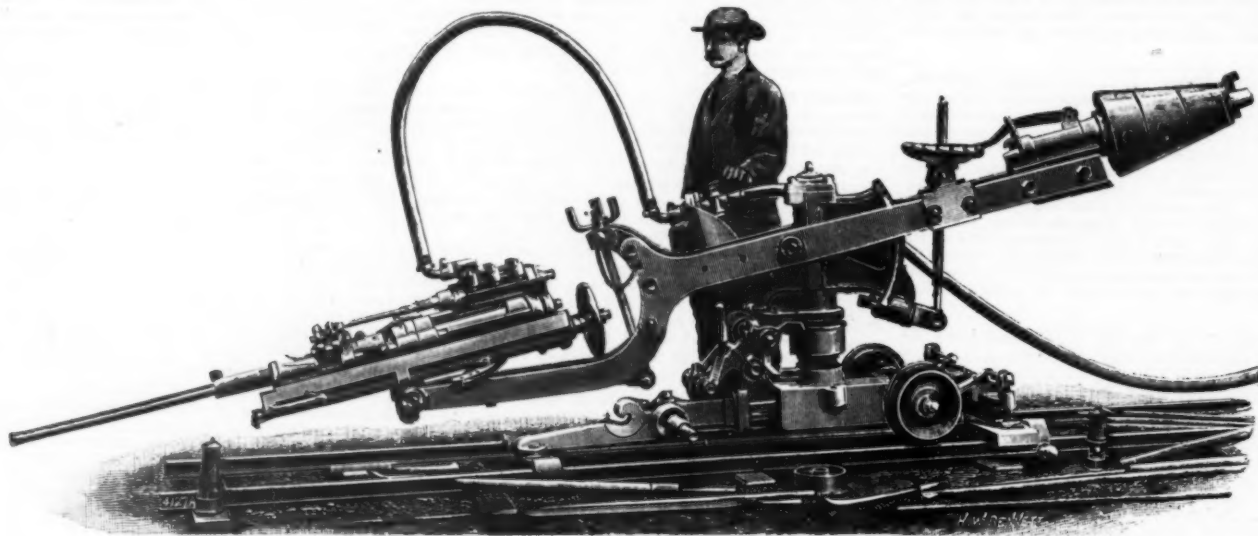


FIG. 1.

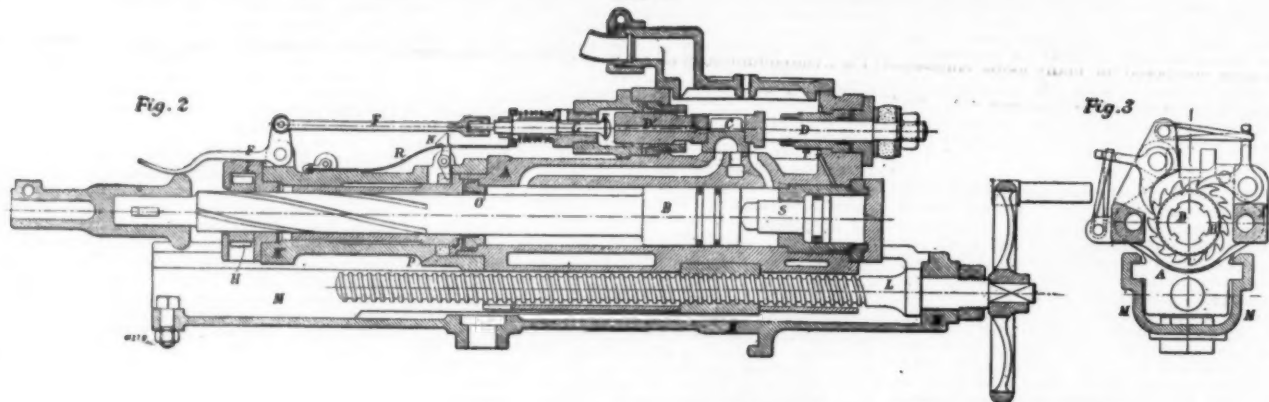


Fig. 2

Fig. 3

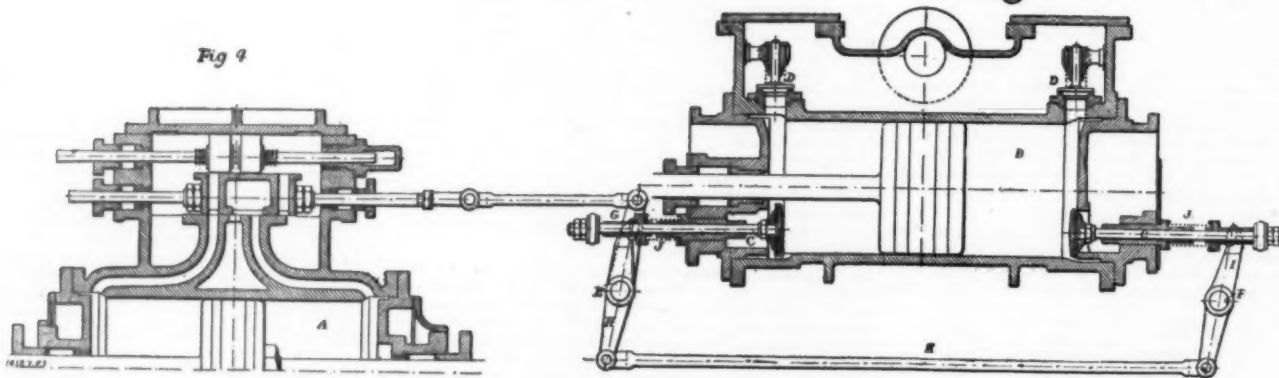


Fig. 4

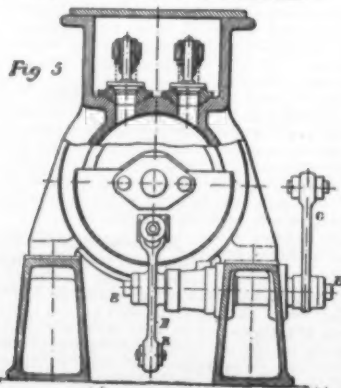


Fig. 5

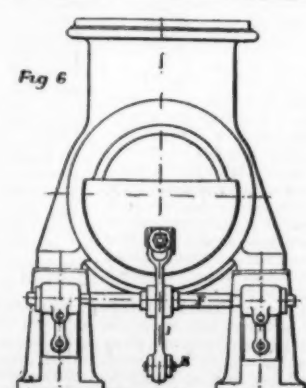


Fig. 6

ing or withdrawing the drill; N, the safety cam; P, the rubber cushion; R, the spring for stopping the piston at the end of its stroke; S, the auxiliary cushioning piston.—Engineering.

RIGHT AND LEFT HANDED ARMATURE WINDING.

By C. C. HAWKINS, M.A.

ALTHOUGH the question of the "hand" of an armature winding may appear an easy one, and the rules

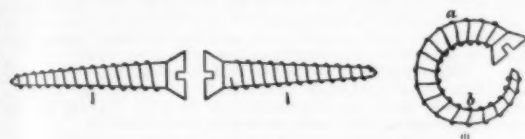


FIG. 1.—R.

which determine it are indeed simple, yet in the office or workshop these rules may have to be applied instantly and with certainty to somewhat complicated cases, and this is apt to be a perplexing matter unless the governing principles are thoroughly understood. The "hand" of a screw, by reason of which the movements of rotation and translation are connected together in two definite ways, is a fundamental fact of mechanics familiar to all. Further, a coil wound in an orderly manner round an axis presents so evidently a true analogy to a screw thread that the same difference

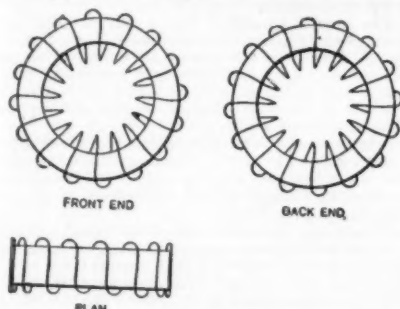


FIG. 2.—R.

between a right handed and left handed direction of winding is immediately recognized. But in the case of the armatures of continuous current dynamos, two separate questions may arise, and the distinction between the two is not always made sufficiently clear to students. Every armature consists of a number of loops, or of coils composed of many loops, connected together into a system by joining the end of one to the beginning of the next. Thus we may ask: What is the "hand" upon which the loops or coils of the armature are wound? And this ends the matter with alternators. But with continuous current armatures we may also ask a second question, viz.: What is the "hand" of the system on which the separate coils or

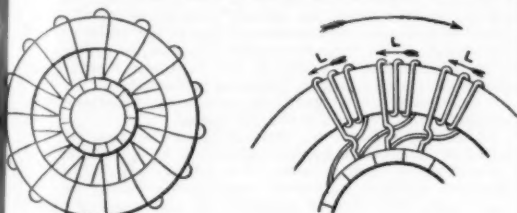
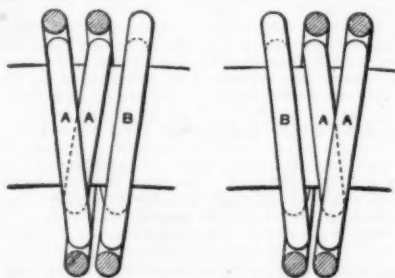


FIG. 3.—R.

FIG. 4.—R.

sections are connected together? The screw analogy is then applied, not only to the actual winding of the coils, but also by a further extension to their system of connection. Upon the first question depends the direction in which with a given field and rotation the induced potential rises in each coil; upon the second, the general direction in which the potential rises in the armature as a whole. As a rule, the hand of the system is the same with the hand of the coils, but this is not always and necessarily so, as is amply proved by the fact that in certain cases the actual loops have no



Commutator End; L.

Commutator End; R.

FIG. 5.

hand at all; yet in such cases the system still has a "hand" assigned to it by analogy and conventional agreement.

The most convenient formula by which to test the "hand" of an armature coil is the following: "If in any helix with its axis placed horizontally an observer starts from the upper portion of a loop, and traces it toward himself, and thence onward, he will be led to another loop further to his right if the helix be right handed, or further to the left if the helix be left handed

(Rule I). A right handed screw is a right handed screw, however we look at it, so that it is a matter of indifference whether we are standing on one side or the other when we apply the formula (cf. i and ii, Fig. 1); or, if the same be coiled into a ring, the observer may start from either the outside or inside of the ring so long as it is always the upper portion of a loop (e. g., in iii, Fig. 1, either from a or b) from which he commences to trace the thread toward himself. But the important corollary to be deduced from the circular screw when viewed from the side (as in Fig. 1, iii) is that if we start from any part of the thread on the out-

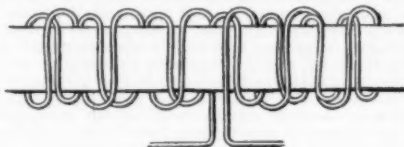


FIG. 6.—R.

side of the circle and trace it toward our point of view, we pass round the circle in a clockwise direction if the thread be right handed, and in a counter clockwise direction if it be left handed. This corollary will be found to furnish the criterion by which the second of our two questions is answered.

In the continuous current ring or discoidal ring armature, if each section of the winding as marked by the commutator segments is a simple loop, the "hand" of the loops and the hand of the system as a whole are one and the same question, and the answer to the one must necessarily be the answer to the other. The loops combine into a simple helix (Fig. 2) and our first rule is immediately applicable. It is immaterial at which end of the armature we stand, or where the commutator segments may be placed. If the commutator be formed by the external portions of the loops, as in some Continental multipolar machines, then, in applying Rule I, we start from a segment and trace it toward ourselves, and thence through the interior of the ring.



FIG. 7.

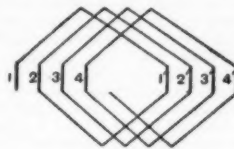


FIG. 8.

If the commutator is not arranged on the external periphery, then, when we start from any external wire and trace it toward ourselves, we are led to a segment and thence onward round the commutator in a clockwise direction if the winding be right handed as before. It makes no difference at which end we stand—e. g., in Fig. 3 the commutator might be at either end or centrally situated in the interior. But in the ordinary armature where the commutator is at one end, if we start from a commutator segment we must fix the direction of tracing with reference to the end at which we stand. It is simplest to consider the armature from the commutator end, and our second rule therefore takes the following form for ring armatures: "With a commutator at one end and standing at that end, if we start from a commutator segment and trace the winding away from our point of view through the interior of the ring, we pass round the segments in a clockwise direction if the



FIG. 9.—R.

armature system be right handed, or in a counter clockwise direction if it be left handed (Rule IIa)."

If in a ring armature each section is composed of several loops in one layer on the outside, the hand of the system should be the same as the hand of the coils. It need not be so, as shown by Fig. 4, where the direction of each coil of three loops is left handed, while the general system is right handed. The winding then progresses round the armature in one direction while the coils themselves progress backward against this direction, and, in consequence, the commutator connections unnecessarily cross the width of the coil. Further, if the coils are in the same field, and the general direction of the rise of potential round the commutator or armature is shown by the large arrow (Fig. 4), the rise of potential in each coil is in the opposite direction, as shown by the small arrows; hence the difference of potential between adjacent turns is a maximum and



Side B turned up.

FIG. 10.



Side A turned up.

FIG. 11.

equal to twice that of one coil, which is a disadvantage. Thus, the arrangement of Fig. 4 would not practically be used, but it serves to illustrate how the system has metaphorically a "hand," no matter what may be the hand of the separate coils. We require to know the general direction of the current into or out of the brushes, and this is determined by the system of connection. In order, then, to find the conventional hand of the system, all that we have to do is to stand at the commutator end and trace the winding

through the interior of the ring away from our point of view; we then pass from segment to segment round the commutator in a clockwise direction if the system is right handed. We need only follow one loop in each coil, and by so doing we virtually describe an imaginary helix as it were on the top of the real coils, and according to the hand of this helix the armature is right or left handed. Thus, if we follow one loop out of each set of three in Fig. 4, we in effect describe upon the actual coils the right handed helix of Fig. 3.

If in each section of a ring armature the turns are to be arranged in more than one layer, and the coil has a width of more than one turn, it is usual to commence

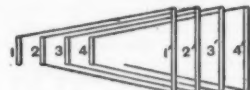


FIG. 12.—R.

winding the coil at or near the center of the total length of wire in the coil, so as to bring both the free ends to the outside layer. Under these circumstances the hand of the system should be the same as the hand of the bottom layer, since this avoids unnecessary crossing of the width of the coil by the commutator connections. The minimum number of turns per section which come under this rule is three, as seen in Fig. 5, which shows two such sections; the hand upon which the system is connected up should then be the same as that of the coil which has a lower layer of two turns, i. e., coil, A A, in Fig. 5. This coil, A A, must be wound first, so that if the armature is to be right handed we must start to wind from the right, and if left handed from the left. With a larger number of turns per section, the layers of each section are alternately right and left handedly wound; if the number of layers on the outside be two or any even number, the ends fall in the center of the coil (Fig. 6), while if the layers be three or any uneven number, they come to the outside edges, but in all

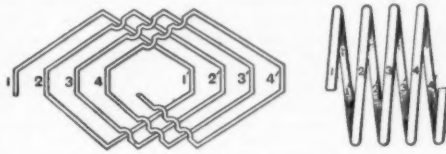


FIG. 13.—L.

cases the sections should be connected up with the same hand as that of the bottom layer of each coil.

Just as a watch spring may be coiled up in a clockwise or counter clockwise direction, but has no hand until its inner end is pushed or pulled through it, so a flat coil such as might form part of the armature of a disk alternator (Fig. 7) has by itself no hand. In exactly the same way, from the mere representation of a coil on the flat, such as Fig. 8, we cannot find out the hand; we must know which wires are underneath and which lie on the top where they cross one another. Fig. 8 may thus stand for three distinct cases. First, let the wires to the right lie above those to the left, as indicated in Fig. 9 by the small overreaching half circles at each end. The winding is then right handed, as our fundamental rule will show. If we imagine a core to be passed through the loops as they are situated in Fig. 9, the wires on the side, B, will be at the top (Fig. 10) in the same order as in Fig. 9. Starting, then, from the upper portion of any loop, such as 1', and trace



FIG. 14.—L.

ing it toward our point of view, we are led on to another wire, 2', which is further to our right. If side, A, be brought up to the top, as in Fig. 11, the wires will run toward the right in the order 4, 3, 2, 1—the reverse of Fig. 9—and again by Rule I, the winding is seen to be right handed. When Fig. 9 is translated into the long and short bars of an ordinary drum armature, with end connectors, 1' 2' 3' 4' must be the long bars, since they cross over the end connectors, and we thus get Fig. 12. In order to test the hand of such a diagrammatic winding by our first rule, we must start from a long bar on the top of the armature, and trace it toward our point of view. To start from a short bar on the top of the armature is tantamount to starting from the lower portion of a loop in a ring armature, instead of the upper portion.

Secondly, the wires to the left of Fig. 8 may lie above those to the right. We then get Figs. 13 and 14, which



FIG. 15.

are the exact reverse of Figs. 9 and 12, and the winding is left handed.

A third case still remains, in Fig. 8. Let the wires to the right lie above those to the left at one end of the armature and below them at the other end. We thus get in Fig. 15 a combination of half of Figs. 9 and 13, and the winding of the loop has no hand at all. If a core be inserted through the loop as shown at the side of Fig. 15, it is seen that the winding is not a helix but an involved knot; yet it forms a perfectly valid drum winding. When translated into a bar armature with

end connectors, the bars are of the same length (Fig. 16), but set so that at each end of the completed armature alternate bars project, and the same bar does not project at both ends.

If a drum armature has only one loop in each section, and is wound as in Fig. 9 or Fig. 13, it is right handed in the first case and left handed in the second case, the hand of the system being necessarily the hand on which the loops themselves are wound. If a commutator is connected to the junctions at either end of Fig. 9, let us start to trace the winding from a segment, when standing at the commutator end; then if we proceed away from our starting point down a wire that forms one of the lower set leading away from the commutator, we pass round the commutator in a clockwise direction. Contrariwise, if a commutator be connected to either end of Fig. 13, and, standing at the commutator end, we proceed away from the commutator down one of

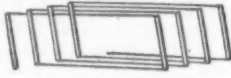


FIG. 16.

the lower layers of wire, we pass round the segments in a counter clockwise direction. Our second rule therefore takes the following form in drum armatures: "Standing at the commutator end, if we start from a commutator segment and trace the winding away from our point of view down the lower arm of a loop and so round to the next segment, we pass round the commutator in a clockwise direction if the armature be right handed, or in a counter clockwise direction if it be left handed (Rule IIb)." The condition "down the lower arm of a loop" is the counterpart of the condition "through the interior of the ring" in the case of ring armatures. In a bipolar armature the lower arm of a loop evidently leads away to the under side of the core which we imagined to be threaded through the loops as they are shown in Figs. 9 and 13, and the analogy is clear, although it is not so evident in multipolar drums, where the coils are comparatively flat. If the winding is composed of bars and end connectors and the commutator is attached to the ends of the long bars, the rule becomes even simpler: we must always proceed away from the segment which forms our starting point down an end connector, and not down a bar. It is quite immaterial on which side of the shaft any connector passes, except so far as the length of an end connector is affected. If the commutator is attached to the center of evolute end connectors, then as we pass down a segment we come to the two arms of the connector, one of which forms part of the outer whorl of spirals and the other part of the inner whorl; in this case, we must always proceed down the arm which is in the inner set of spirals next to the armature core, and so to the end of a short bar.

In the case of Fig. 15 all the above holds equally good; but now, since the loops have no hand, we are dealing simply with the metaphorical "hand" which is conventionally assigned to the system. In this case the hand of the system varies with the end of the armature to which the commutator is attached, since the bars which project at one end do not project at the other end.

Fig. 17 shows that in all cases, if we pass round the segments by Rule IIb, in a clockwise direction, we are virtually describing on the actual loops a right handed

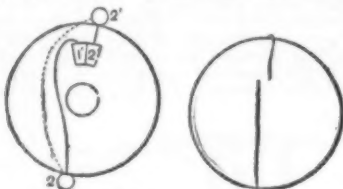


FIG. 17.—R.

spiral, and, as far as the question of the system is concerned, it is quite immaterial, not only on which side of the shaft the end connectors pass, but whether any bar at the far end projects or does not project.

If each section of the drum armature has several loops, these may be wound according to either Figs. 9 or 13, and the hand of the system should then follow the hand of the loops, for the same reasons as in a ring armature. Fig. 15 would not be a practical method for a wire wound armature with several loops per section, but is perfectly feasible with a bar wound armature, and in this case the hand of the armature is fixed according to the end at which the commutator is attached.

In single phase alternators the coils are, as a general rule, alternately right and left handed, although whether this is so depends entirely upon what is the most convenient method of joining together the separate sections. In any case the system, as a whole, has no hand, since the coils do not unite into a spiral.—The Electrician, London.

ART AND NATURE IN LANDSCAPE GARDENING.

IN the spring we receive the most frequent inquiries from amateur planters about shrubs, trees and herbs for what they call "decorative planting." Many persons who have acquired new homes in the country or in the suburbs of cities are moved to beautify them in some way, and the first thought that occurs to every one is to secure an abundance and variety of what are known as "ornamental" plants. It is not our purpose to make out any such list, and even if we considered it advisable, the season is too far advanced to begin to arrange for planting. Nevertheless, these requests suggest a word or two of counsel which may as well be repeated at one season as another. We have no novel doctrine to advance, nothing but a few principles which do not change every year like fashions in millinery.

The spring planting of trees and shrubs is practically over for the year, and where these have been planted by novices it is probable that they have been badly selected and planted in improper positions. Neverthe-

less, this fact is not utterly discouraging, for when once a land owner begins to take any serious interest in his home grounds it is probable that the habit will grow on him and become a lifelong and increasing source of refreshment and refinement. We have said that both planning and planting by novices are, as a rule, worse than unsatisfactory, for if there is any art which needs original aptitude, special training and long experience for the highest success, it is the art of planting public and private grounds. This statement will be admitted by most men of cultivation, but practically they do not realize its truth. An engineer or a botanist is considered qualified to plan a public garden. Places of remarkable natural beauty, when once they are acquired by a city, are often put under the control of commissioners, who may have a fair education and experience in business, and if they have in addition to this what is known as good taste they are esteemed perfectly competent to preserve the scenes, to develop their charms and to devise facilities for exhibiting them. Gentlemen of wealth who have some cultivation consider themselves quite able to lay out their own places, especially if they have the help of some journeyman gardener, who often has no appreciation of the character and beauty of the grounds, and whose first work will be to despoil the scenery of all that makes it really valuable, and then begin the work of decorating it with flower beds, golden elders and purple-leaved shrubs of various kinds. The worst part of the matter is that the men who are utterly lacking in their ability to foresee what a piece of ground will look like a few years after they have set out to "improve" it, are quite unconscious of their lack of qualification, and have not the slightest idea that any such qualification is needed. Even if they were capable of taking such a look into the future, they would not be competent to pass any intelligent judgment on the result of their work. The fact is that no one but a man of genuine creative faculty can see just what elements in a landscape are the essentials that ought to fix its character, or can estimate the relative proportional importance which should be given to each one so as to produce the best combined effect and invest the whole with a charm which is distinctly its own.

This brings us again to the point that for the treatment of any piece of ground, public or private, the counsel of a landscape gardener of recognized standing should be at once taken. The novice who insists upon improving his own grounds must educate himself through his own mistakes. If he begins at the wrong end and buys a great many more novelties and oddities among trees and shrubs than he needs, and then wanders around in his lot for a place to plant them, he will soon see that his crowded grounds have no unity of expression or of purpose. If, however, he will endeavor to set before his mind a clear and definite picture of what his house and grounds together are to look like, and will then attempt to construct his picture, he will not be led to choose a plant simply because the catalogue pronounces it beautiful, but because it is necessary to complete his idea and give expression to his thought. All this sounds very simple, but he will find it no easy task to create such a picture even in imagination. But if he has in mind a design which is reasonably distinct, and for the details of which he can give intelligent reasons, he will certainly learn some things by his experience which very few of his fellow men understand. When he studies his house and grounds not only as a unit, but in their relation to what is beyond them, and endeavors to shut out what is distracting or unsightly and preserves within a fitting framework the view of distant prospects that are pleasing, and when he attempts to provide for conveniences in the way of buildings and walks and place them so that they do not disturb his picture, he will learn that it requires not only taste, but hard study, to solve the complex problem that he has in hand. He will learn, too, that even within the modest limits of his home are there chances for an individuality of plan and for a refinement and finish in the details which an artist of the first rank would not deem unworthy of his powers.

The objection is sometimes made to the work of artists in landscape that, after all, purely natural scenery is the most impressive, and the art of man can only interfere with nature to belittle it or weaken its strongest effects. But the true artist aims to help, and not to hinder nature. Even the broadest landscape can be improved, that is, adapted to human use and enjoyment, if it is treated in a reverent spirit. We do not attempt to thwart nature when we open her thickets and help magnificent trees in their development. We are working with nature if we encourage a screen of foliage deep enough to exclude the intrusion of some disagreeable object, or if we open vistas which will uncover to us the sky line made by a mountain range. Nature alone does not spread out for us broad stretches of meadow, but if we come to her aid she will give to us all the turf we need. That is, the real artist emphasizes and intensifies here or subdues and qualifies there. He uses the art that mends nature, working in harmony with, and not against her. The truth is not thoroughly comprehended by persons who consider the true work of the landscape gardener to be the planting of flower beds and of ornamental shrubs. But, after all, it is this broad and catholic art which alone is satisfying everywhere, and which is just as useful in the preservation of the Yosemite Valley or the scenery of Niagara as it is in planning a pastoral park or the grounds about a country house.—Garden and Forest.

ON THE ASCENT OF WATER IN TREES.*

WITHIN the last few years the problem of the ascent of water has entered on a new stage of existence. The researches which have led to this new development are of such weight and extent that they might alone occupy our time. It will be necessary, therefore, to avoid, as far as possible, going into ancient history. But it will conduce to clearness to recall some of the main stepping stones in the progress of the subject.

The two questions to be considered are: (1) What is the path of the ascending water? (2) What are the forces which produce the rise?

(1) The first question has gone through curious vic-

issitudes. The majority of earlier writers assumed that the water traveled in the vessels. This was not, however, a uniform view. Cessalpinus, 1583, seems (Sachs' "History of Botany," English Trans., p. 451) to have thought that water moved by imbibition in the nerves. Malpighi and Ray held that the vessels serve for air and the wood fibers for the ascent of water. Hales ("Vegetable Statics," p. 130), who believed in the sap vessels as conduits, speculated on the passage upward of water between the wood and the bark. Also (loc. cit., p. 19) that water may travel as vapor not in the liquid state. In the present century, Treviranus (Sachs' "History"), 1835, held that water traveled in vessels; De Candolle, 1832, that the intercellular spaces were the conduits. In Balfour's "Manual of Botany," 1863, vessels, cells and intercellular spaces are spoken of as transmitting the ascending water.

The change in botanical opinion was introduced by the great authority of Sachs,* who took up Unger's view† that the transpiration current travels in the thickness of the walls as water of imbibition.

Then followed the reaction against the imbibitionists—a reaction which has maintained its position up to the present time. Boehm, who had never adopted the imbibition theory, must have the credit of initiating this change; his style was confused and his argument marred by many faults, but the reaction should in fairness be considered as a conversion to his view, as far as the path of the traveling water is concerned. Nevertheless, it was the work of others who principally forced the change on botanists, e. g., Von Höhnell (Pringsheim's Jahrb., xii, 7879), Elfving (Bot. Zeitung, 1882), Russow (Bot. Centr., xiii, 1883), R. Hartig ("Ueber die Vertheilung," etc., Untersuchungen aus dem Forst. Bot. Inst. zu München, ii and iii), Vesque (Ann. Se. Nat., xv, p. 5, 1883), Godlewski (Pringsheim's Jahrb., xv, 1884), and others.

(2) The second question has a curious history and one that is not particularly creditable to botanists generally. It has been characterized by loose reasoning, vagueness as to physical laws and a general tendency to avoid the problem, and to scramble round it in a mist of vis à tergo, capillarity, Jamin chains, osmosis and barometric pressure.

An exception to this accusation (to which I personally plead guilty) is to be found in Sachs' imbibition theory, in which, at any rate, the barometric errors were avoided, though it has difficulties of its own, as Elfving has pointed out.

But the most hopeful change in botanical speculation began with those naturalists who, concluding that no purely physical causes could account for the facts, invoked the help of the living elements in the wood. To Westermaier (Deutsch. Bot. Ges., Bd. i, 1883, p. 371) and Godlewski (Pringsheim's Jahrb., xv, 1884) is due the credit of this notable advance, for whether future research uphold or destroy their conclusions, it claims our sympathy as a serious facing of the problem by an ingenious and rational hypothesis.

We may pass over the cloud which arose to witness for and against these theories and proceed at once to Strasburger's great work (Leitungsbahnen, 1891), in which, with wonderful courage and with the industry of genius, he set himself to work out the problem de novo, both anatomically and physiologically. In my opinion it is difficult to praise too highly this great effort of Strasburger's.

Strasburger's general conclusion is now well known. He convinced himself that liquid can be raised to heights greater than that of the barometric column in cut stems, in which the living elements have been killed. Therefore, the cause of the rise could not be (1) barometric pressure, (2) nor root pressure, (3) nor could it be due to the action of the living elements of the wood. His conclusions may be stated as follows:

(a) The ascent of water is not dependent on living elements, but is a purely physical phenomenon.

(b) None of the physical explanations hitherto made are sufficient to account for the facts.

Strasburger has been most unjustly depreciated, because his book ends in this confession of ignorance. I do not share such a view. I think to establish such distinct, though negative, conclusions would be, in this most nebulous of subjects, an advance of great value. Whether he has established these conclusions must of course be a matter of opinion. To discuss them both would be to go over 500 pages of Strasburger's book, and will not here be attempted. Conclusion (a) that the ascent is not dependent on living elements must, however briefly, be discussed, because it is here that the roads divide. If we agree with Strasburger, we know that we must seek along the physical line: if we differ from him, we are bound to seek for the missing evidence of the action of the living elements.

Schwendener's Criticism.—Perhaps the best plan will be to consider the most serious criticism that has been published of Strasburger's work, namely, Schwendener's paper "Zur Kritik," etc. (K. Preuss. Akad., 1892, p. 911.)

Schwendener objects that although a continuous column of water cannot be raised by air pressure to a greater height than that of the barometric column, yet when broken into a number of columns, as in the case of a Jamin chain, that a column considerably over 10 m., even as much as 13 or 14 m., of water can be suspended. This, though not fatal to Strasburger's conclusions, is no doubt a serious criticism. For if 13 m. can be supported, some of Strasburger's experiments are inconclusive. He finds that a branch can suck up a poisonous fluid to over 10 m., and, as above explained, argues that all ascent above that height, not being due to barometric pressure or to the living elements (since the wood is poisoned), is for the present inexplicable. But, if Schwendener is right, the effect above 10 m. may have been due to atmospheric pressure. Askenasy (loc. cit. infra, 1895, p. 6) objects to Schwendener that the supposed action cannot be continuous. By repeating the diminution of air pressure at the upper end, the movement of water becomes less

* Physiol. Vegetale (French Trans.), 1868, p. 235, and more fully in the Lehrbuch. Sachs also partially entertained Quincke's well-known suggestion of movement of a film of water on the surface of vessels.

† Sitz. k.k. Akad. Wien, 1868. Dixon's and Joly's paper in the Annals of Botany, September, 1896, gives evidence in favor of a certain amount of movement of the imbibed water.

‡ It is of interest to note that Hales, in speaking of the pressure which he found to exist in bleeding trees, says: "This force is not from the root only, but must also proceed from some power in the stem and branches." (Veg. Statics, 1727, p. 130.)

* A paper read before Section K of the British Association at the Liverpool meeting, by Francis Darwin, F.R.S. (Revised January 20, 1897.)—From Nature.

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and less, and sinks to almost nothing. Askenasy adds, moreover, that the amount of water which could be raised according to Schwendener's theory would be very small.

One difficulty about Schwendener's theory is that the result depends on the length of the elements of which the chain is made up (such element being a water column plus an air bubble). In his paper, "Ueber das Saftsteigen" (K. Preuss. Akad., 1886, p. 561), he finds that the elements of the chain in *Fagus* equal in round numbers 0.5 mm. In his paper (K. Preuss. Akad. Sitz., 1893, p. 842), "Wasserbewegung in der Jamin'schen Kette," he finds the element in *Acer pseudo-platanus* = 0.9 mm., in *Acer platanoides* and *Ulmus effusa* = 0.2. But the calculation (1892, p. 984) is based on the existence of a chain in which the water columns are each 10 mm. in length, a condition of things which he allows does not occur in living trees.

But even if we allow Schwendener to prove theoretically the possibility of a Jamin chain being raised to a height much greater than that of a barometric column, I do not think he invalidates Strasburger's position. Schwendener's idea necessitates the traveling of a Jamin chain as a whole, i. e., the translation not only of water, but of air bubbles. But this cannot (as Strasburger points out) apply to his experiments on conifers, in which the movement of air to such an extent is impossible ("Ueber das Saftsteigen," Hist. Beitr., v, 1893, p. 50). And for the case of dicotyledonous woods, Strasburger has shown that the movement of air is excluded by the fact that transverse walls occur in the vessels at comparatively short distances. In *Aristolochia* the sections may be as long as 3 m., but in ordinary woods, according to Adler (as quoted by Strasburger), we get: *Alnus*, 6 cm.; *Corylus*, 11 cm.; *Betula*, 12 cm.; *Quercus*, 57 cm.; *Robinia*, 69 cm. These facts seem impossible to reconcile with Schwendener's views.

Action of the Poisonous Fluids in Strasburger's Experiments.—The question whether the living elements are killed in Strasburger's experiments is of primary importance in the problem.

Schwendener does not criticize it at length; he seems to assume (Zur Kritik, loc. cit., 1893, p. 935)—as far as I can understand—that since the death of the tissues extends gradually from the cut end upward, there are living cells in the upper part which may still be effective. He also doubts "whether the cells were always killed at once." The first objection of Schwendener's may or may not be sound, but in any case it does not (as Strasburger points out) account for the experiment (Hist. Beitr., v, p. 12) in which an oak stem was poisoned by pieric acid, and three days afterward was placed in fuchsin pieric. The second reagent had to travel in tissues already killed with pieric acid, yet a height of 23 m. was reached.

The question whether the reagents kill the cells in Strasburger's experiments does not lend itself to discussion. It is difficult to see how they should escape, and we have Strasburger's direct statement that the living tissues were visibly killed. It must not be forgotten that, in some of his experiments, the death of the tissues was produced by prolonged boiling, not by poisons (Leitungsbahnen, p. 646). Thus the lower 12 m. of a *Wistaria* stem were killed in this way, yet liquid was sucked up to a height of 108 cm. In the *Histolog. Beitr.*, v, p. 64, he has repeated his air pump experiment, using a boiled yew branch, and found that eosin was sucked up from a vessel in which almost complete vacuum was established; so the action of living elements and of atmospheric pressure was excluded.

On the whole, the balance of evidence is, in my judgment, against the belief that the living elements are necessary for the rise of water. In other words, I think we should be justified, from Strasburger's work, in seeking the cause of ascent in the action of purely physical laws.

Strasburger's General Argument from the Structure of Wood.—It seems sometimes to be forgotten that, apart from the physiological or experimental evidence, there is another line of argument founded on the structure of wood. Strasburger's unrivaled knowledge allows him to use this argument with authority, and he seems to me to use it with effect. Thus (Hist. Beitr., v, p. 17) he points out that though in coniferous wood the action of the living elements in pumping water is conceivable, yet this is far from being universally the case. He points out that in the monocotyledons such theories meet with almost unconquerable difficulties. This is, he says, especially the case in *Dracena*. He goes on to point to difficulties in the case of such dicotyledons as *Albizia*. The case may perhaps best be put in the generalized manner that Strasburger himself employs (loc. cit., p. 20). If the living elements are of such importance as Godlewski, Westermarck and Schwendener hold, we ought not to find these difficulties; we ought rather to find structural peculiarities pointing distinctly to the existence of such functions. For instance, we ought to find the tracheal water path actually interrupted by living elements which might act like a series of pumping stations one above the other. It should, however, be remembered that if we deny the importance of the medullary rays and other living elements in raising water, we ought to be able to point more clearly than we can at present to the function of the medullary rays and to structural adaptations to these functions.

The Work of Dixon and Joly and of Askenasy.—I now pass on to the recent work in which Strasburger's indications to search along a purely physical line have been followed. In the paper of Dixon and Joly (Proc. Roy. Soc., vol. lvii, 1894, No. 340) the suggestion was for the first time made that the raising of water to the tops of trees depends on the quality which water possesses of resisting tensile stress. To most botanists the existence of this quality is a new idea. To believe that columns of water should hang in the tracheals like solid bodies, and should, like them, transmit downward the pull exerted on them at their upper ends by the transpiring leaves, is to some of us equivalent to believing in ropes of sand. The idea is more fully treated in the Phil. Trans., vol. clxxvi, and in the Annals of Botany, vol. viii. The same leading idea occurred independently to Askenasy, who has published it in the Verhand. a. d. naturhist. med. Vereins Heidelberg, N. F., Bd. v, 1895, and N. F., Bd. v, 1896.

Askenasy has earned the gratitude of his botanical readers by giving some of the evidence which demon-

strates the existence of this property of water.* A tube a meter in length was filled by Donny with water, and the remaining space was as far as possible freed from air. When the tube was placed vertically, the water column at the upper end hung there and could not be made to break or free itself from the glass by violent shaking. Berthelot filled a thick wall capillary tube completely with water at 28°-30° C.; it was allowed to cool to 18°, so that the space left by the shrinking of water was filled with air. It was then sealed up and again warmed to 28°-30°, so that the air was dissolved in the water. When it was allowed to cool again it retained its volume, filling the tube completely. A slight shake, however, allowed the water to break and return to its proper volume at 18° with the appearance of a bubble of air. In this experiment the water contained air, yet it seems to have been until recently assumed by some physicists that to show cohesion, water must be air free. If this were the case, the application of the principle to plants would be impossible. Dixon and Joly have, however, proved that this is not so, and this forms an important part of their contribution to the subject.

They also investigated the amount of tension which water under these circumstances will bear, and found it about equal to seven atmospheres. If, therefore, the leaves at the top of a tall tree can exert the requisite upward pull on the water in the trunk, it seems certain (if no other condition in the problem interfere) that the pull can be transmitted to the level of the ground. This opens up the question whether the leaves can exert this traction on the water in the tracheals, and what is equally important, are there any factors in the problem incompatible with the theory?

(1) The Sucking Force of the Leaves.—In Dixon and Joly's first paper (Phil. Trans., pp. 563, 567) they assume that tractional force is given by the meniscuses "formed in the membranous réseau of the evaporating cell walls," as well as possibly by the osmotic action of the cells of the mesophyll. We shall take these theories in order. Our knowledge of the cell wall does not allow us to believe in the existence of pores visible with even the highest powers of the microscope. Dixon's more general expression (Proc. Roy. Irish Acad., Jan. 13, 1896, p. 767), "surface tension forces developed in the substance of the walls of the evaporating cells," is therefore preferable. But Askenasy seems to me to state the matter much more conveniently by using the term "imbibition" (loc. cit., 1895, p. 10). The force with which vegetable membranes, e. g., the thallus of *Laminaria*, absorb water has been demonstrated by Reinke and others, and the existence of such a force is familiar to botanists.

Both Askenasy (loc. cit.) and Dixon and Joly (Annals of Bot., September, 1895) have pointed out that the force of imbibition, or the surface tension forces, as the case may be, can exert a tractional effect on the water in the tracheals, when the turgescence of the mesophyll has been destroyed. But Askenasy in his original paper (1895), Dixon in the January, 1896, paper, and again Askenasy in his second paper (March, 1896) have also considered the imbibitional or surface tension forces in connection with the turgescence cell. It must clearly be understood that this does not remove imbibition from the problem. The sun's heat causes the evaporation of the water with which the walls of the mesophyll cells are imbibed; this water is replaced by imbibition from the cell sap. The concentration of the cell sap so produced maintains the osmotic force of the cell, which again exerts suction on the water on the tracheals.

I have now given, in its simplest form, the modern theory of the rise of water. Apart from the main idea, it combines the points of several familiar views. Imbibition becomes a factor of paramount importance, though not in the way that Sachs employs it. The suspended threads of water remind us of Elfvig's capillary theory, while the living element factor is represented by the turgescence mesophyll cells.

Resistance.—It is not possible to discuss the question whether the tractional forces in the leaf are sufficient for the work imposed on them until we know what is the resistance to the passage of water through wood. For it is clear that the work done by the leaf includes not only the lifting of a given column, but the overcoming of the resistance to its flow.

The resistance to the flow of the transpiration current is in want of further investigation. Janse (Pringsheim's Jahrb., xviii, 1887, p. 1) has discussed the question, and points out (loc. cit., p. 36) that two kinds of resistance must be reckoned with. The first (which he calls statical) is illustrated by means of a cylinder of *Pinus* wood fixed to the short arm of a J tube filled with water, when it was found that in five days the level of water in the long arm was only 1 mm. above that in the short arm. That is to say, when time enough is given, the resistance is practically nothing. Janse has also investigated the resistance to the passage of water flowing through wood at the rate of an ordinary transpiration current. His method seems to me open to criticism, but this is not the place to give my reasons. His experiments give a wide range of results. With *Pinus strobus* a pressure of water equal to ten times the length of the wood was required to force water through at a pace equal to the transpiration current. In *Ginkgo* the pressure was twenty-one times the length of the wood. Strasburger (Leitungsbahnen, p. 779) has repeated Janse's experiment, and finds a column "several times the length of the object" necessary. Nägeli ("Das Mikroskop," 2d edit., p. 385) found that 760 mm. of mercury were needed to force water through fresh coniferous wood at the rate of $\frac{1}{2}$ mm. per second, i. e., at 180 mm. per hour. If we allow one meter per hour as a fair transpiration rate (Sachs' "Arbeiten," ii, p. 182), we get a pressure of 5 atmospheres required to produce such a flow. To return to Janse's experiments: even if we assume that the resistance (expressed in water) = 5 times the length, it is clear that with a tree 40 m. in height the resistance of 20 atmospheres has to be overcome. This would not be a

pressure greater than that which osmotic forces are able to exert, but when we come to a tree of 80 m. in height, and a resistance of 40 atmospheres, the thing becomes serious.* A great difficulty in the question of resistance is that the results hitherto obtained are (though here I speak doubtfully) much greater than those obtained by physicists for the resistance of water flowing in glass capillaries. Until this discrepancy is explained it is rash to argue from our present basis of knowledge.

Is the Osmotic Suck Sufficient?—The osmotic force of a turgescence cell is usually measured by its power of producing hydrostatic pressure within the cell. Thus, De Vries ("Untersuchungen über d. mechanischen Ursachen der Zellstreckung," 1877, p. 118) investigated the force necessary to extend a plasmolyzed shoot to its original length; Westermarck (Deutsch. Bot. Ges., 1883, p. 382) the weight necessary to crush a tissue of given area; Pfeffer (Abh. k. Sachs. Ges., 1893), the pressure exerted by growing roots; Krabbe (K. Akad. Berlin (Abhandlungen), pp. 57, 60, 1884) the pressure under which cambium is capable of maintaining its growth.

The figures obtained by these naturalists have a wide range; it may be said that the hydrostatic pressure varies between three and twenty atmospheres.

Another method is to ascertain the osmotic strength of the cell sap in terms of a KNO_3 solution, and calculate the pressure which such a solution can produce. According to Pfeffer (Pfeffer, Phys., i, p. 53), 1 per cent. KNO_3 with artificial membrane gives a pressure of 176 cm. = 2.3 atmospheres. De Vries (Pringsh. Jahrb., xiv, p. 527) calculates that in a cell a 0.1 equivalent solution (practically = 1 per cent.) gives a pressure of three atmospheres. We may, therefore, take it as between 2.5 and 3 atmospheres. Now, De Vries found that beetroot requires 6 to 7 per cent. KNO_3 to plasmolyze it; this would mean 15 to 21 atmospheres. I do not know what is the greatest pressure which has been estimated in this way. Probably Wieler's (Pringsh. Jahrb., xviii, p. 82) estimate of the pressure in the developing medullary ray cells of *Pinus sylvestris* at twenty-one atmospheres is the highest. It is clear that investigation of the osmotic capacity of leaves for high trees is wanted, also investigations of the variation in osmotic power produced by varying resistances in the flow of the current. The experiments of Pfeffer and others show that the osmotic strength of cell sap is capable of great adaptation to circumstances—cells respond by increased turgescence to various stimuli. Whether they can respond sufficiently to account for the ascent of water is another question.

My own opinion is that the question of resistance to the flow of water is a difficulty which the authors of the modern theory have not sufficiently met. Unless it can be shown that the resistance to the flow of water in wood is less than that indicated by existing researches, we must face the fact that we do not at present know of osmotic forces which we can suppose capable of raising water to a greater height than forty meters.

Continuity of the Water in the Tracheals.—The theory we are considering apparently requires that there shall be continuous columns of water from leaf to root, because a break in the column means a collapse of the machinery. This seems at first sight a fair assumption, though I doubt its complete correctness. It is in any case worthy of discussion. It has been constantly insisted on by Sachs and others that at the time of most active transpiration the vessels contain air, and not water. It is, therefore, a violent disturbance of our current views to believe in continuous columns of water.

For evidence on this point we are chiefly indebted to Strasburger. It is a remarkable fact that he should, without any theory to encourage such a view, have come to the conclusion that approximate continuity of water columns is a condition of primary importance, and that he should have made out the cogent fact that the whole of the albumen need not be simultaneously occupied by a transpiration current; parts of it may be so occupied, while parts of it are filled with air, and do not function as waterways. This is a valuable contribution to knowledge, and to the adherents of the new theory it is priceless; the very existence of their hypothesis may depend on it.

Strasburger's statements and reasoning are by no means accepted by every one; for instance, Schwendener refuses to take them seriously (K. Preuss. Akad., 1892, p. 931).

Strasburger has microscopically examined the condition of the tracheals as regards air. He found in the spruce fir in July "almost no air bubbles" in the wood of the current year, but air in considerable quantity in four-year-old wood. In the same month *Pinus Salzmanni* (Laricio) showed scattered bubbles in the spring wood of last year, and more in the autumn wood. In a larch there were only very occasional bubbles in the two last years' wood. In the silver fir the current year's wood was practically free from air; the air increased in the inner rings. *Tsuga canadensis* had no air in this year's wood, only a little in last year's, and an increasing quantity in the older rings, the fifth being very rich in air. In February, *Pinus strobus* had hardly any air in this year's wood, and the silver fir was all but free from it in the youngest ring. *Robinia* in July had the youngest wood almost air-free. *Ficus elastica* and *spuria*, various acacias and willows gave vessels not entirely free from air, but nearly so. He concludes (loc. cit., p. 688) that the path of the transpiration current is not absolutely free from air. The younger wood, which especially functions as the water carrier, is the most free.

Dixon and Joly quote Strasburger's results, which they consider sufficiently favorable to their views. They rely, in addition, on the impermeability of wet cell walls to air, isolating the conduits in which air has appeared; and on the possibility that the air may be redissolved under root pressure (Phil. Trans., p. 572)—an idea well worth testing.

* He gives reference to Donny, Poggendorff's Annalen, 67 Bd. (148 Bd. d. g. R.), 1845, p. 502; Berthelot, Annales de Chimie et de Physique, 8, 3, t. 50, 1860, p. 232; Worthington, Proc. Roy. Soc., vol. 1, 1892, p. 453.

† Phil. Trans., vol. 186, p. 570. With ethyl alcohol Worthington records a tension of 17 atmospheres. See Proc. R. Soc., vol. 1.

‡ Sachs' "Text Book," edit. iv., Eng. Tr., p. 679, describes evaporation taking place in the cell wall, which makes good the loss by imbibition.

§ Strasburger (Leitungsbahnen, p. 777) observed equilibrium established a good deal quicker.

* Schwendener's experiments, K. Preuss. Akad., 1886, p. 579, do not particularly bear on this question.

† It is possible that the rate of the ascending water is much less than is usually assumed. Thus Schwendener (K. Preuss. Akad., 1886, p. 584) calculates from an observation of v. Höbner that the transpiration current in the stem of a tall beech was only 2 meters per day.

‡ Pfeffer, "Abhand. der k. Sachs. Ges.," xx, p. 309; Eichenhagen, Untersuchungen aus d. Bot. Inst. a. Tübingen, 1889; Stange, Bot. Zeit., 1892.

§ Leitungsbahnen, p. 683 et seq.; Russow in 1882 (Bot. Centr., vol. xiii, 1883) observed similar facts in the distribution of water and air.

I think Strasburger's facts are not so favorable to their theory as these authors believe; in the same way it seems to me that Askenasy is rash in saying* that the tracheals in many cases contain continuous columns of water. It is true that this statement does not affect the validity of his general argument, since he faces the undoubted occurrence of air bubbles in many cases. This is undoubtedly necessary, and, fortunately, we can once more turn to the Leitungsbahnen. Strasburger states that he has seen water creep past the air bubbles (Leitungsbahnen, pp. 704, 709; see also "Hist. Beitr." v. p. 70) in coniferous tracheids. The best evidence for this seems to be the fact mentioned (ibid., p. 79), that the part of a single tracheid in front of an air bubble gets red, with absorbed eosin, though the neighboring tracheids are colorless. This clearly suggests the creeping round the bubble which Strasburger believes in. Schwendener (Zur Kritik, etc., p. 921) has been unable to confirm Strasburger's microscopic observations, and, moreover, denies the physical possibility of the phenomena. I am unable to judge of the validity of Schwendener's theoretic objections, and must leave this point. It is a question of great importance whether it is possible that, on the breaking of a column of water, a film of water remains surrounding the air bubble, and capable of holding the two columns together. If this is impossible, we must suspend our judgment until we know more of the contents of the tracheals.

To sum up this part of the subject, we may believe that the tracheals in their youngest condition may contain water in continuous columns, since the cambium cells from which they arise certainly contain fluid. But we know also that this condition is not absolutely maintained, since Strasburger has shown that the young wood contains air, though in small quantity. We must, therefore, believe either (1) that the transpiration current is able to travel past the air bubbles, or (2) that tracheals partly filled with air may again become continuous waterways by solution of the air. If we adopt the first alternative, we must believe that the film of water between the bubble and the wall of the vessel is able to bear such a tensile stress that it can serve to link the column above with the column below the bubble. But this is analogous to trusting a rope so nearly cut through that only a few threads remain intact. With regard to the second alternative, we have, at least, indications from Strasburger's work that a tracheal partly filled with air does not necessarily remain permanently functionless (see Leitungsbahnen, p. 692).

The isolation of the Tracheals.—There are a number of points connected with the structure and properties of wood which ought to be considered in relation to the modern theories. Want of space forbids my doing more than referring to two of them.

The resistance which the wetted cell wall offers to the passage of undissolved air is a point on which many writers have laid stress. It is clear that, on any theory of the movement of water in the tracheals, it is essential that air should not filter into the waterway. This necessity is not, however, stronger in the case of the modern theories we are considering. The pressure tending to fill the tracheals with air from outside cannot be greater than atmospheric pressure and since the wetted cell walls of gymnospermous wood can resist the passage of air under a pressure of about an atmosphere,† we need not fear criticism of the theory on this ground. The above remarks seem, however, to be needed in face of the frequently recurring statement that wet wood membranes are impermeable to free air. Schwendener had some good remarks on this head (Zur Kritik, p. 945).

Strasburger has called attention to the important subject of the localization or isolation of vessels, or of certain lines of tracheids. When this is possible we may have one set of tracheals containing continuous water columns, while neighboring ones contain air at negative pressure (see Histolog. Beiträge, v. p. 87). This is especially important in connection with the Dixon-Joly-Askenasy theory, since if there were no such isolation, a functioning tracheal containing a continuous column of water would give up its water to one which was not functioning. In other words, the inactive tracheals would, by negative pressure, suck water from the active ones. In the coniferous trees the young wood is cut off by the absence of pits in the tangential walls; from free communication with the older wood, where air is more frequent.

In the same way the valvular closure of the pits by the aspiration of the pit membrane comes to be a subject of much importance.

At present I merely wish to show by a couple of examples the necessity of a complete study of the minute structure of wood in relation to the modern theories. It is, at least, a hopeful fact for Messrs. Dixon, Joly and Askenasy that we cannot point to anything in the anatomy of wood which is absolutely inconsistent with their views. Finally with regard to the question at large whether we are friends or opponents of Messrs. Dixon, Joly and Askenasy's theory, the broad facts remain that water has the power of resisting tensile strength, and that this fact must henceforth be a factor in the problem. There are difficulties in the way of our author's theory, but it is especially deserving of notice that many of these difficulties are equally serious in the case of any theory which excludes the help of the living elements of the wood, and assumes a flow of water in the tracheals. The authors have not only suggested a vera causa, but have done so without multiplying difficulties. There is, therefore, a distinct balance in their favor.

Huxley, quoting from Goethe, makes use of the expression thatige Skepsis. It is a frame of mind highly appropriate to us in the present juncture, if we interpret it to mean a state of doubt whose fruit is activity, and if we translate activity by experiment.

Among the metallurgical exhibits at the Scandinavian Exhibition, at present being held in Stockholm, there are some samples of steel billiard balls. These balls, which are made by a secret process out of Mitis cast steel, are hollow, and are claimed to be equal in all respects to ordinary billiard balls.

* Verhandl. Naturhist. Med. Vereins Heidelberg, 1896, p. 16.

† Leitungsbahnen, p. 732. Nageli and Schwendener, Das Mikroskop, 2d ed., p. 367, give 250 cm. of mercury.

‡ Strasburger discusses, in this connection, the existence of tangential pits in the autumnal wood (see Leitungsbahnen, p. 713).

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